Methods Improvement Workshop for the Sihipbuilding Industry

U.S. DEPARTMENT OF TRANSPORTATION
Maritime Administration and the U.S. Navy

in cooperation with
National Steel and Shipbuilding Company
San Diego, California

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FINAL REPORT

TASK 8-87-1

METHODS IMPROVEMENT WORKSHOP
FOR THE
SHIPBUILDING INDUSTRY

Prepared By
National Steel and Shipbuilding Company
Harbor Drive and 28th Street
San Diego, California

For
SNAME Ship Production Committee
Industrial Engineering Panel SP-8

Under The
National Shipbuilding Research Program

September 1991

FOREWORD

This "Final Report" includes introductory pages of Preface, Executive Summary, Workshop Overview, Student Evaluation, and Workshop Attendance. Following these introductory pages is the workshop Workbook and Appendices used in the workshop.

The Methods Improvement Workshop for the Shipbuilding Industry was conducted under the direction of the National Shipbuilding and Research Program. This project was a cooperative cost shared effort between the Maritime Administration and National Steel and Shipbuilding Company to improve productivity thus reducing shipbuilding costs.

With this goal in mind, the study followed closely the project outline approved by the Society of Naval Architects and Marine Engineers (SNAME) Ship Production Committee.

Ms. Kimberly M. Thomadsen, SP-8 Panel Chairman, and Mr. James R. Ruecker, NSRP Program Manager of National Steel and Shipbuilding Company, were responsible for project development and presentation. Program definition and technical direction was provided by the members of the SP-8 Industrial Engineering Panel.

PREFACE

In 1981, the SP-8 Industrial Engineering Panel held a five-day Methods Improvement Workshop at the Institute of Industrial Engineers in Atlanta, Georgia. The material covered during this first workshop included a number of industrial engineering techniques suited for shipyard applications. The training was extensive. The intent of the program was to train participants to go back to their yards and instruct others in the application of the techniques. This first workshop was a "train the trainer" program.

In 1983, shipyard representatives recommended that another workshop be presented to further expand the shipyard supervisors exposure to the Methods Improvement process. In order to reach more people, the original five-day program was formatted into a two-day program and was presented in four locations: San Diego, California, Green Bay, Wisconsin, New Orleans, Louisiana, and Newport News, Virginia during the fall of 1985. The material covered was similar to the 1981 version except the intent of this series of workshops was to train the participants to a level of understanding so they could return to their yards and apply what they had learned. The workshop was attended by 77 people with 71% from private yards and 23% from public yards.

Due to the success of the earlier Methods Improvement Worshops industry, representatives once again requested the SP-8 Industrial Engineering Panel to sponsor another series of workshops on the subject. In the fall of 1987, the National Shipbuilding Research Program Executive Control Board gave approval to proceed with the development of the program. The material from the previous workshops was modified to incorporate the most successful topics. It also included other techniques which had demonstrated to be applicable in the shipyard environment. Techniques were reduced to those that would be most beneficial to the yards.

The objective of the program was to train as many shipyard supervisors as possible in methods improvement techniques. They could then return to their yards and improve operations within their control. In order to achieve this objective, the workshops were conducted at five locations: Sturgeon Bay, Wisconsin, Mare Island, California, Philadelphia, Pennsylvania, Newport News, Virginia, and Honolulu, Hawaii. The two-day workshop sessions were held during the fall and winter of 1988-89.

EXECUTIVE SUMMARY

The objective of this project was to train production supervisors, superintendents, non-production supervisors, and managers in analytical problem-solving techniques.

The SP-8 Industrial Engineering Panel of SNAME recognized that many of the United States shipyards did not have in-house industrial engineering capabilities. In order to assist the yards in developing analytical techniques, a methods improvement prgram was developed specifically to train shipyard management in these missing skills.

A series of workshops were presented near shipyards to make it available to as many shipyard supervisors as possible. Participants learned:

* To foster an attitude of promoting change in their organization.
* Analytical techniques to pinpoint low performance areas.
* Steps to improve production operations.
* Steps to sell and implement methods improvement ideas.

The content of this report was provided to all participants as a student reference manual.

The project was a success. The workshop was attended by more than 150 people. The student evaluations indicated that it was well-received and more workshops were desired by the industry on the subject. They also suggested that workshops on other industry studies would benefit the U.S. shipyards.

WORKSHOP OVERVIEW

The workshop was divided into five sessions. Those sessions included: Need for Change, Problem Identification, Data Collection Techniques, Desired Outcomes, and Selling Techniques. Each one was designed to educate the participants in how to apply Methods Improvement Techniques.

Session One addressed the Need for Change from the perspective that the world is in constant change. We need to recognize that fact and act accordingly. We have been complacent with this need to improve productivity in the U.S. shipyards. It was emphasized that improvement in production starts with the individual and that the participants were in a position to improve their organization's productivity.

The next session covered the first step that must be taken in any improvement program which is to objectively identify the problem areas. The process was covered in detail (where to start and how to utilize several techniques to identifying perceived causes). Emphases was put on Nominal Group Techniques (NGT), Brainstorming, and Cause and Effect Analysis. An exercise was conducted in NGT to demonstrate its capabilities of increasing a group's capacity to generate creative ideas and understand problems and their possible solutions.

Session Three reviewed Data Collection Techniques which have proven successful in shipyards. Recording data is a key element in the Methods Improvement Process. The accuracy of the information collected on a current situation is crucial to the success in implementing a new method. It is this data that provides the basis for both the evaluation of the current method and the development of a new one.

The students were introduced to several data collection techniques which would assist them in recording the facts in a clear and concise manner. Emphasis was put on work sampling as it has proven to be the most effective Industrial Engineering tool available for direct shipyard application. The workshop participants were trained in "How to Conduct a Work Sampling Study" using eight essential steps for a successful study. The process was re-emphasized with a work sampling exercise using 35-mm slides simulating a fitting operation on a panel line.

In addition to the in-depth introduction to work sampling, a concentrated training was given on the use of flow process charts utilizing several exercises. Process charting is an effective tool which can be used to analyze shipyard operations. Flow charting provides a compact

picture of a process which points out areas in need of correction, improvements, or possible elimination.

Session Four addressed what should come out of the problem-solving process. It is important to identify your desired outcome in order to avoid confusion. When the problem has been clearly defined, the next step in the process is to identify a workable solution. The initial step is to generate ideas. They can be obtained through an NGT or brainstorming session. Then evaluate the critical elements of the problem to ensure the solution resolves the situation. This is an effective means of narrowing down the field of solutions in order to achieve your desired outcome.

In the last session, the subject of selling the idea was covered. The key to selling a new way of doing business is to start with total involvement from the bottom of the organization to the top. It was stressed that everyone that is affected or needs to approve the new method must be involved in the improvement process. The person performing the task plays as much of a role as management in how successful the new procedure will be.

The workshop material was also supplemented with real life examples of the techniques presented. A number of participants also told their experiences with them. This sharing by the instructors and participants provided those unfamiliar with the techniques a picture of how to improve productivity within the shipyard environment.

STUDENT EVALUATION

At the end of each workshop, the participants were requested to evaluate the presentation. The following is a summuary of their impressions.

* The overall rating of the workshops on a scale of 1 to 20 was a 16 (Excellent).

* 81% indicated they felt they could apply what was presented while 15% thought that it could help them to some degree. Only 4% said it would not be beneficial.

* When asked if the subject level was too elementary, just right or too advanced, 80% thought it was just right.

* TOP FIVE IDENTIFIED BENEFITS DERIVED FROM THE WORKSHOP:

  1. How to perform a work sampling study
  2. Industrial Engineering refresher course
  3. Awareness to the Methods Improvement Process
  4. Developed skills in how to identify problems and their solutions
  5. Better understanding of how to utilize Data Collection Techniques

* FOUR MOST INTERESTING TOPICS:

  1. Work Sampling
  2. Nominal Group Techniques
  3. Flow Process Charting
  4. Actual Shipyard Examples

ATTENDANCE

LOCATION	DATES	PRIV YARDS	PUB YARDS	OTHER PRIV	GOVT AGEN	TOTAL
Sturgeon Bay Wisconsin	9/15-16 1988	30	0	0	3	33
Mare Island California	10/20-21 1988	0	27	1	4	32
Philadelphia Pennsylvania	11/07-08 1988	3	32	3	2	40
Newport News Virginia	11/10-11 1988	19	2	1	1	23
Honolulu Hawaii	1/12-13 1989	5	14	1	4	24
	TOTALS	57	75	6	14	152

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I. NEED FOR CHANGE

The United States has been and continues to be the most productive nation in the world (Figure 1). But the news is not all good in terms of productivity growth. In terms of relative rates of growth, using gross domestic product per employee and making comparisons on a purchasing-parity basis, productivity for the United States is poor compared to other developed nations 1 Figure 2). The U.S. rate of 0.8% per year is eclipsed by that of Korea at 4.7% and Japan at 2.8%, as may be expected, but most European countries growth rates are also a full percentage point better than that of the United States. The result of low productivity growth rates has been felt by all of us through declining competitiveness in international markets, lowered standards of living, unemployment and so forth.

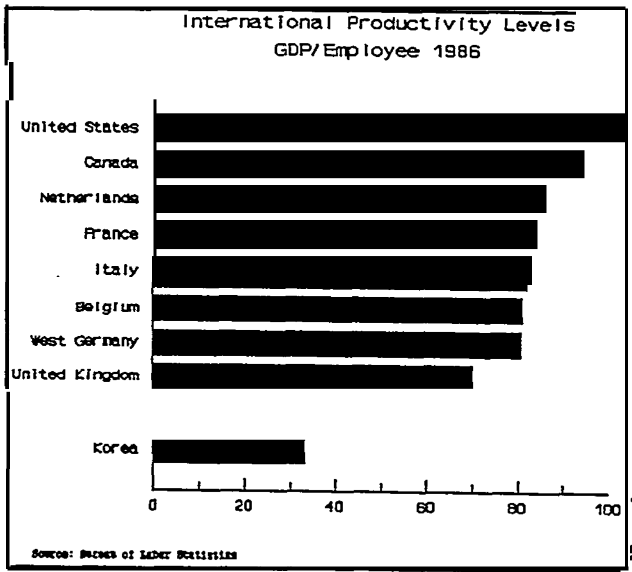

Figure 1

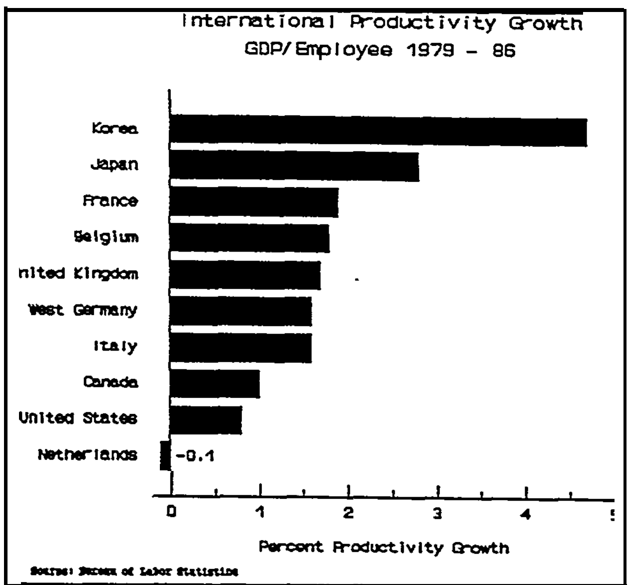

Figure 2

In the United States productivity has increased since 1982 which is mainly due to the strong performance in manufacturing. Unfortunately transportation is one of the worst

performers.

Looking at U.S. ship production as of May 1, 1988 there were no commercial ships over 1,000 gross tons under construction in the United States. The active U.S. shipbuilding mobilization base has declined from 27 shipyards in 1982 to 20 shipyards in 1988, with several of the remaining shipyards without work or in Chapter 11. Since 1982 U.S. shipyards employment has decreased by 30 percent, with 32,000 jobs lost.

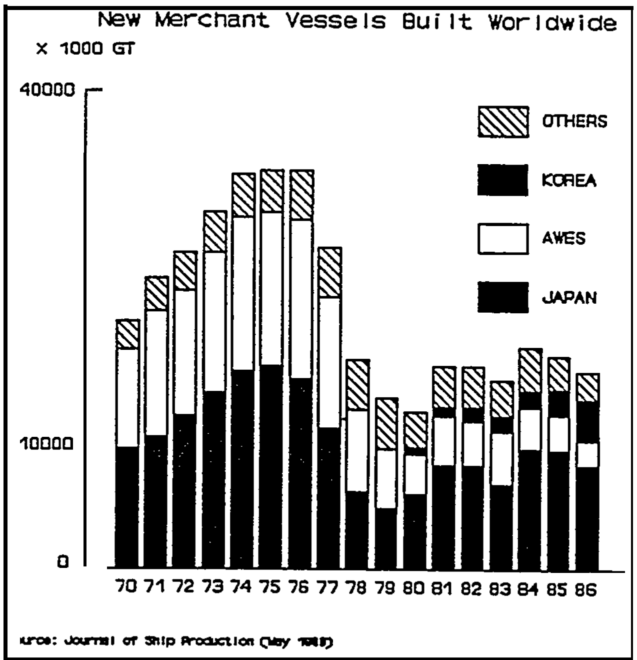

Figure 3

On the International side, commercial shipbuilding **continues to be dominated by Japan (Figure 3). Market share of commercial production in Korea has continued to grow through the 80's.**

A U.S.-based tanker owner prepared a comparison of estimated costs for 90,000-dwt tankers built in the United States, Northern Europe, and Japan as of 1981 (Figure 4). The major differences can be found in the labor and overhead estimates.

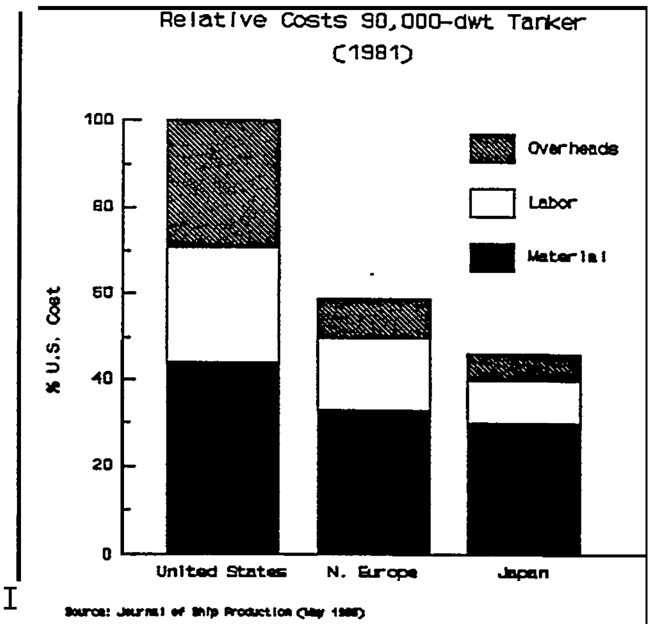

Figure 4

For the same 90,000-dwt tanker constructed in 1981 for delivery in 1983 a comparison of labor hours and costs can be seen in Table 1

Table 1 Comparison for the 90 000-dwt tanker

	U.S.A.	N. Europe	Japan
Labor hours	100%	57%	46%
Labor cost	100%	51%	35%

The need for productivity improvements in shipbuilding is all toc evident from this data. Since 1981 improvements have been made by. some U.S. shipyards, and from a productivity perspective the ratic for Japanese yards relative to U.S. yards is now approximately 1:2.0 to 1:2.5.

The U.S. must maintain competitive levels of productivity in key industries just to maintain its standard of living in today's increasingly competitive world market. To maintain competitive levels of performance, industries must be effective and efficient; maintain high quality; be innovative in process; and maintain competitive levels of productivity.

It is this need, that has sparked the development of this methods improvement workshop. To continue to improve performance, shipyards, as well as other industries, need to take a closer look. at how and where changes can be made to improve performance. Equally important is the need to strive to make the recognized methods improvements happen.

Your Role in Change

Although every manufacturing company should constantly strive for methods improvements, it is imperative for companies in the shipbuilding industry. Improvements must be made in all areas by people at all levels within a company.

Everyday, each of you encounters problems you would like to see solved. Undoubtedly, you have good ideas as to how the problem could be solved. Now is the time to stop talking about problems and thinking about solutions and actually start implementing solutions. In fact, you can probably think of so many problems that the idea of solving all of them seems overwhelming. You've got to start somewhere so start with the smaller problems in areas you can affect directly. It is probably unwise to tackle a big. problem in your first run through the methods improvement process. Break the big problem down into its manageable elements and tackle each small problem, one by one. Most big problems are made up of smaller problems whose effects are compounded anyway.

Every supervisor should be looking at improvements he or she can make in his or her particular area. The first thing each supervisor needs is an open mind. Every area and function should be open to questions concerning whether improvements can be made. Certain areas and functions required more improvements than others and, naturally, they should be addressed first. You shouldn't be afraid to admit there are problems in your area or department, because most likely the problems were there before you were. There is nothing wrong with being the one to finally solve some problems. Another requirement of anyone involved in methods improvement or problem solving is a questioning attitude. Throughout this workshop, you will hear the importance of the questioning attitude discussed; it cannot be overemphasized. Without it, you cannot reap the full benefits of successful implementation of the method

improvement process and as a supervisor, you will be responsible for inspiring the need for change and improvement in those who work for you.

Besides an open mind and questioning attitude, you will need initiative and persistence. You will repeatedly encounter people who do not think changes need to be made, or who think you are just "stirring things up." "But it has always been done that way" is a phrase you will rapidly grow tired of. It doesn't matter if something has always been done a certain way; if it isn't working, then it needs to be changed. You will also hear people say that they've been through processes like this before without successful results. That may be true, but doing nothing is not an alternative if you want to help your company stay in business.

If upper management support is present, the implementation of the methods improvement process will be easier (not easy) than if it is absent. Upper management support may enable you to tackle bigger, interdepartmental problems. However, if upper management support is lacking, you can still work on making beneficial changes in the area which you control directly. And chances are, you can sell management on the importance of methods improvement if you successfully implement changes in your own area or department. Nothing succeeds like success in selling an idea.

As supervisors, you have the knowledge of which particular problems need to be addressed in your area, and as a supervisor, you should be concerned with improving the quality of work life for the people that work for you as well as yourself. Also, you have the technical expertise to help discern a good solution from a bad one when you reach that phase. This workshop will provide you with guidelines to follow throughout the methods improvement process, from the problem selection stages to selling your ideas to management and labor.

Implementing new ideas is not easy; inevitably there will be resistances from someone. That is why it is so important to involve the "right" people. The "right" people are those who will be most affected by whatever change is implemented. If you involve the "right" people from the beginning and let them contribute their ideas, they will develop a willingness and eagerness to implement change and will facilitate rather than resist implementation.

As a supemisor, you are in a position to effect change. With your technical expertise, the basic guidelines provided in this workshop, and the involvement of those affected you will have the ability to make improvements in the area under your supervision.

Selecting Participants

Solving Problems From Within

When beginning the methods improvement process it's important to realize the need for involvement by those who ultimately will be required to implement the developed solutions. The more you involve those who will be affected in the improvement process, the greater the likelihood of acceptance and commitment to the solution developed. We know that change occurs when persons accept the need for it, make their own decisions in favor of it, and determine for themselves the directions it should take. By moving to the lowest appropriate level of the organization to develop solutions, you will increase the probability of developing high quality solutions that will meet with minimal resistance during implementation. Realize that workers ideas are often better than those of management because they are closer to the work.

When is Participation Appropriate?

Although this workshop promotes the use of participative problem solving whenever possible, it's important to realize that participation is not always the most appropriate process for accomplishing tasks. There are times when autocratic, authoritative problem solving or delegation to an individual is appropriate. Participative problem solving is most appropriate for the following purposes.

1. To allow those who feel they have knowledge about a subject or problem to become involved.

2. To develop consensus on controversial issues, problems, and ideas for performance and productivity improvement.

3. To allow representatives of those organizational systems who are going to be affected by an issue, problem, decision, or implementation a chance to influence the approach and results.

4. To avoid poorly thought-through action and explore a variety of possible effects.

However, there are also times when participation is not suitable.

1. When one person clearly has greater expertise on the subject than others.

2. When those to be affected by a decision acknowledge and accept that expertise.

3. When there is a "hip pocket" solution - an easy, clear, acceptable solution the manager of the department or area already knows is the "tright" answer.

4. When the issue, problem, decision, or implementation is part of someone's regular job assignment, and it is not clear that the person will accept a group approach.
5. When there is no time for participation.

It's important to realize that participation is not always the most appropriate way to solve problems.

> "Many American managers have fallen into the trap of assuming participation, often in the form of quality circles, is the "one best way for today". This is reinforced by the turbulent, competitive times we face and the Japanese success with small group activity. This is analogous to the pilot of a jet liner in a terrible storm with instrument panel out, going out of the cockpit, back to the passengers and asking them to circle-up and help him get out of the storm." (anonymous)

Most of the techniques to be discussed in this workshop can be performed by an individual or a group. However there are some specific areas to be covered that are designed for a group or participative approach to methods improvement.

II. PROBLEM IDENTIFICATION

Where to Start

The easiest part of methods improvement is coming up with a list of problems. You may even be thinking, "I know what my problems are. How will this workshop help me?" This workshop will provide you with a structured and logical approach to solving problems. A significant advantage of this approach is that it is far easier to sell your solution to a problem if you have followed a logical process. It also provides those who developed the solution with added confidence, knowing they have thoroughly analyzed the problem and selected the most appropriate, not first, solution.

Methods improvement can only be accomplished with an open mind. Do not take any method for granted, no matter how long it has been done one way or how good the present method seems. Remember, there is always a better way.

The technique of work simplification, more than anything, relies on good common sense and a few logical steps. First, establish a job or function you want to improve. For the first few runs through the methods improvement process, look for jobs that have many delays, bottlenecks, poorly maintained machines, excessive set-up times, etc..

Second, break down the job so it can be effectively analyzed. It is much easier to analyze a job when it is broken down into small elements so attention can be paid to one element at a time. It is also much easier to solve a significant problem in parts rather than trying to tackle the entire problem at once.

A number of tools and techniques can be used to break down a job. These will be covered in depth in this course. However, one very

important tool is worth mentioning again at this time: the "questioning" attitude required for methods improvements. Throughout the methods improvement process, when looking at current or proposed methods, it is important to ask questions. "why" is the most important and should be asked first, followed by What, Where, When, Who, and How. Question every aspect of the job or method under consideration. Of course, you won't make changes regarding every aspect, but it is important to evaluate each. Don't assume anything you can ask a few questions about to get an answer.

<u>What to Analyze and Measure</u>

When considering whether a method study investigation of a particular job should be carried out, certain factors should be kept in mind. These are:

- o Economic considerations
- o Technical considerations
- o Human reactions

1. <u>Economic considerations</u> will be important at all stages. It is obviously a waste of time to start or to continue a long investigation of the economic importance if the job is small, or if it is one which is not expected to run for long. The first questions must always be: "Will it pay to begin a method study of this job?" and "Will it pay to continue this study?"

   Obvious early choices are:

   - o "Bottlenecks" which are holding up production operations.
   - o Movement of material over long distances between shops, or operations involving a great deal of manpower to where

there is repeated handling of material.

- o Operations involving repetitive work using a great deal of labor and liable to run for a long time.

2. Technical considerations will normally be obvious. The most important point is to make sure that adequate technical knowledge is available with which to carry out the study. Examples are:

   (a) The use of preconstruction primer versus raw steel in the construction process might bring increased productivity of facilities and labor, but there may be technical reasons why a change should not be made. This calls for advice of specialists in welding, burning, coatings, etc.

   (b) A machine tool constituting a bottleneck in production is known to be running at a speed below that at which the high-speed cutting tools will operate effectively. Can it be speeded up, or is the machine itself not robust enough to take the faster cut? This is a problem for the machine-tool expert.

3. Human Reactions are among the most important factors to be taken into consideration, since mental and emotional reactions to investigation and changes of method have to be anticipated. If it appears that the study of a particular job is leading to a great deal of unrest or ill feeling, you may decide to leave it alone for the time being, however promising it might be from the economic point of view. If other jobs are tackled successfully and can be seen by all to benefit the people working on them, opinions will change and it will be possible, in time, to go back to the original choice.

Preliminary Questions

When selecting a job for method study, it will be helpful to have a standardized list of preliminary questions to be answered. This prevents factors from being overlooked and enables the suitability of different jobs to be easily compared. It is important to ask general questions about the jobs you are considering studying before you begin examining a specific problem. This background information will assist you in selecting an appropriate problem to analyze. A sample list of questions is given below which would be appropriate if considering problems in a shop situation. Some of the questions will apply to other situations, however, it is best to develop a list of general questions to suit your individual needs.

1. Production and operation
2. Suggested limits of investigation
3. Particulars of the job:
   (a) How much is (many are) produced or handled per week?
   (b) Will more or less be required in future?
   (c) How long will the job continue?
   (d) How many employees are employed on the job:
      a. directly?
      b. indirectly?
   (e) How many employees are there in the trade?
   (f) What is the average output per day?
   (g) what is the daily output:
      a. of the best employee?
      b. of the worst employee?
   (h) Has the job any especially unpleasant or injurious features? Is it unpopular:
      a. with workers?
      a. with supervisors?

4. Equipment:

   (a) What is the approximate cost of plant and equipment?

   (b) What is the present ratio of Machine Running Time to Machine Available Time?

5. Layout:

   (a) Is the existing space allowed for the job enough?

   (b) Is extra space available?

   (c) Does the space already occupied need reducing?

6. Product:

   (a) Are there frequent design changes causing modifications? (to what?)

   (b) Can the product be altered for easier manufacture?

   (c) What quality is demanded?

   (d) When and how is the product inspected?

   (e) How much rework is there?

7. What savings or increase in productivity may be expected from a method improvement:

   (a) Through reduction in the work content of the product or process?

   (b) Through better machine utilization?

   (c) Through better use of labor?

   (Figures may be given in money, man-hours or machine-hours, or as a percentage).

Item 2, "suggested limits of investigation", deserves some comment. It is important to set clearly defined limits to the scope of the investigation. Method study investigations so often reveal scope for even greater savings that there is a strong temptation to go beyond the immediate objective. This should be resisted, and any jobs shown up as offering scope for big improvements through method study should be noted and tackled separately.

Such a list will prevent the work-study analysis from going first for a small bench job which will entail a detailed study of the

worker's movements. and yield a saving of a few seconds per operation, unless the job is one that is being done by a large number of operatives, so that the total saving will significantly affect the operating costs of the yard. It is no use playing around with split seconds and inches of movement when a great waste of time and effort is taking place as a result of bad shop layout and the handling of heavy materials.

Possible Criteria for Problem Selection

It is important, especially during the first few runs through the methods improvement process, to select a problem in an area that you can affect directly. Do you, as a group, have the resources, skills, and time to solve a particular problem and implement the solution? The extent of management support will also dictate which problem you should select. Successful implementation of the first few ideas developed will go a long way in selling methods improvements to management and labor.

Developing criteria by which the problem to be solved is selected during the Voting and Ranking phases of the problem selection techniques discussed in the next section is essential. The voting procedure will be improved by asking group members to consider a general set of criteria that all will use. There should be less need to repeatedly discuss various ideas for clarification.

The following is a general list of criteria to consider. The importance and availability of each should be determined before the meeting to select a problem. If there are constraints on the problems which can be selected for study, the participants should be informed, most importantly, before the Voting and Ranking steps. The criteria are not meant to discourage you from selecting a certain problem. They are simply intended to assist you in selecting a problem with a high potential for successful solution

development and implementation.

Time. The time available is the most important determinant of the type of problem that should be selected. If there are strict time constraints, the group members should be aware of them. When time is abundant, it can permit a group to explore a greater number of alternatives and make multiple solution revisions. If the time available is too short, it can severely limit the quality of the solution. Therefore, it is essential to realistically assess the time available for solution development. Otherwise, the group may select a problem that is too complex to effectively handle in the given time-frame. The leader may have to be directive to a certain extent in the problem selection.

People. It is necessary to evaluate the skills, knowledge, experience and expectations of the group to develop the methods improvements. These factors will determine which problems the group can effectively solve. The following questions can be asked about the group to help discern what type of problem should be selected:

- What are the problem solving skills?
- What are the technical skills?
- Is the technical expertise concentrated in one area?
- Are there problems the group should avoid?
- Can the group be innovative?
- Will certain members be reluctant to speak about certain subjects with other members?
- Does the group already have ideas for solutions to certain problems?
- How have past experiences shaped perspectives?
- What are the group's expectations?
- Does the group have a negative attitude?

- Is the group motivated to tackle complex or controversial problems?
- What level of individual commitment is required?
- How much time (per week) is the group willing to devote?
- Are there resources within the company to assist the group if necessary (IE Department)?

There are no pat answers as to how the answers to the above questions should dictate where problems are selected. However, if answers to several questions appear to eliminate certain problems, it is probably wise to direct group against selecting them.

Physical Resources. Physical resources such as equipment and money can also impact the problem. The equipment required may be computer hardware or software or test equipment. If access to needed equipment is limited, this issue should be resolved before a problem is selected. Otherwise, certain problem areas should be eliminated from further consideration.

The availability of funding for capital investments may also eliminate certain problems. If the solution to a problem requires substantial capital investment, management will probably want to see extensive alternative analyses or may even want to appoint its own "task force" to evaluate the situation. Is the group capable of such an alternative analysis? Although the leader of the group does not want to discourage or underestimate the group's abilities, he or she must also be realistic about what the group can do.

<u>Selecting a Specific Problem</u>

Once you have gathered general information about possible areas for methods improvement, you need to select a specific problem to address. Selecting the appropriate problem is critical and should not be done hastily. One technique that is very effective is the

Nominal Group Technique. It is a structured "brainstorming" process which assists groups in making selections that are satisfactory to the entire group. Another technique is classical brainstorming with a voting step added in order to select a specific problem. Both of these techniques will be discussed.

<u>Nominal Group Technique</u>

The Nominal Group Technique (NGT) (Delbecq, 1986) is a powerful tool for increasing a group's capacity to generate creative ideas and understand problems and their possible solutions. The Nominal Group Technique is different from other brainstorming techniques because it allows time for individual thought and reflection before ideas are tossed out to the group. Individual judgments can be tapped and pooled to arrive at decisions that are desirable and acceptable to the entire group. The advantage of using groups in idea generating situations is that they have more complete and diverse states of knowledge than individuals. Thus, the quality of ideas that can be generated by groups is higher. Another distinction of the NGT is that it has a ranking step that incorporates individual judgments of the relative importance of ideas. These judgment are then aggregated after discussion to form a group consensus.

Advantages of NGT

1. Ensures equality of participation among group members.
2. Eliminates harmful effects of a dominant personality.
3. Provides a highly efficient procedure for processing a large number of ideas.
4. Concentrates disagreements on ideas, rather than individuals.
5. Enables members to leave meeting with sense of closure and consensus.

Disadvantages of NGT

1. Lack of external stimulation and sharing of ideas may result in low quality ideas.
2. May not produce unique ideas of other brainstorming techniques.

Steps of the Nominal Group Technique

The steps of the Nominal Group Technique are as follows:

0. Present NGT Question
1. Silent Generation
2. Round-Robin
3. Clarification
4. Voting
5. Ranking
6. Discussion and Reranking (if necessary)

Each step will be discussed in detail.

The NGT is best used in meetings with a specific idea-generating or problem solving objective. The number of participants in a session should be 8-12. NGT sessions typically last 2 - 2 1/2 hours. Usually the sessions are controlled by a facilitator or leader and an assistant. The facilitator/leader can be the production foremen or supervisor directing the group or a member of the Industrial Engineering or Training departments in your shipyard with experience in this or similar techniques. It is important that the facilitator\leader be directive and maintain the pace and focus of the meeting. The assistant can be helpful when recording ideas, distributing materials, and ensuring that the session runs smoothly.

Developing an NGT Question

Before the actual NGT session, the facilitator/leader needs to spend some time developing the question to be asked of the NGT participants in the Silent Generation step. Developing a properly focused question is an extremely important part of the NGT. Otherwise, you will get a lot of information you are not really interested in. The question should be simple and direct.

There are 4 steps in the development of a good NGT question.

1) Define specific objectives of NGT session
2) Illustrate level of abstraction and specificity desired without giving leading examples.
3) Develop several questions.
4) If possible, test questions on another group.

Select the question that elicits the type of responses(s) desired.

The NGT Session

The supplies needed to conduct an NGT session are:

1. Flip Chart
2. Masking Tape
3. Pack of 3 X 5 index cards
4. markers
5. Paper and pencil

It is very important to be able to display all ideas at all times thoughout the session. The flip chart, therefore, is essential.

Introduction

The meeting should begin with a brief introduction to inform the participants of:

1) The purpose of the meeting
2) The steps of the NGT
3) How the results will be used and the next steps

It is imperative that the purpose and importance of the meeting be clear. Uncertainty about the purpose may effect the performance of the group members and discourage open and equal participation.

STEP O: Present the NGT Question

The NGT question whould be written at the top of a worksheet leaving enough space for participants to list their ideas. If the facilitator/leader is asked. to clarify the NGT question, he should ask others in the group to give their interpretation of the NGT question. This is called Self-Priming and is used to reduce any bias introduced when the facilitator/leader clarifies the question or gives examples. Once everyone's responses coincide with the facilitator/leader' s objectives, you can proceed to the first step.

STEP 1: Silent Generation of Ideas in Writing

Procedure/Leader Responsibilities

1. Direct group to write ideas in brief phrases
2. Ask group to work silently and independently
3. Participants should remain silent until all are finished writing
4. NGT leader can write ideas along with other participants
5. This step should last 5-10 minutes

Benefits:

- o Allows time for thinking and reflection
- o Avoidance of interruptions and distractions

It is important that all group members be allowed to work in silence. The facilitator/leader should set an example by refraining from any actions that might be distracting, if not recording his or her own ideas at that time.

STEP 2: Round-Robin Recording of Ideas

Procedure/Leader Responsibilities

1. Clear verbal statement of purpose of step
   a. The objective is to map group's thinking
   b. Ideas should be recorded in brief phrases
   c. Ideas should be taken one at a time from each participant
   d. Variations on a theme are desirable
2. No evaluation or criticism of ideas
3. Record ideas as rapidly as possible
4. Record ideas in words of group members
5. Make entire list visible to all group members at all times
6. Assist in abbreviation only if necessary

Benefits:

- o Encourages equal participation in presentation of ideas
- o Focuses group on problem
- o Enables separation of ideas from personalities to some extent
- o Increases individual’s ability to deal with large number of ideas
- o Provides a written record of the session

This step is extremely important as it provides the basis for all further discussion. The facilitator/leader should simply go around the room, asking each group member for one idea at a time until all ideas are listed. If a group member does not have an idea, the facilitator/leader should move on to the next person. However, the member should be called upon the next time around, in case another idea has occurred to him or her as ideas will be sparked by others already recorded. It is extremely important that the facilitator/leader maintains control of the session. Ideas should only be accepted from a member when it is his or her turn to contribute an idea. The facilitator/leader should contribute ideas in turn just like the other members, if he or she feels comfortable doing so.

Group members should not be allowed to discuss or evaluate ideas at this time as that is the purpose of the next step.

STEP 3: Clarification

Procedure/Leader Responsibilities

1. Objective of this step is clarification of ideas
2. Pace the groupts discussion to avoid focusing or ignoring particular ideas
3. Individuals should not be asked to clarify ideas they suggested
4. Clarification is a <u>group</u> task
5. Duplicate items should be combined or omitted
6. Number items after all have been clarified

Benefits:

o Avoids focusing unduly on a particular problem

- Provides chance to clarify ideas and explain opposing viewpoints
- Allows recording of opposing opinions

The quality of the discussion in this step will determine the resultant quality of the idea selected. The facilitator should read each idea aloud and ask the group members if they have any questions or comments. Group members should feel free to comment on the logic behind an idea or the relative importance of an idea. Disagreements are permissible but should not be allowed to dominate the NGT session. Similar ideas should be combined instead of eliminating one of the ideas. The combination of ideas must be acceptable to all participants. If a participant sees a distinction between the two ideas, then the ideas should be kept separate. Above all, it is important that the facilitator/leader pace the discussion so that all the ideas are discussed.

STEP 4: Voting

Procedure/Leader Responsibilities

1. Have group members select n most important items
   If there are less than 20 ideas listed, select 5 most important; otherwise, select the 8 most important ideas
2. Give group member corresponding number of index cards
3. Write number of item on list in upper left corner. For item #13, write 13 in upper left corner. Write each idea on a separate card.
4. Write phrase describing item in middle of card

Item #13
Identifying Phrase

5. Allow members to take their time selecting the items

Benefits:

- o Obtaining independent judgement in writing reduces peer pressure
- o None of the members can dominate group's decision

Having group members silently select most important ideas is an important aspect of the NGT process. It eliminates peer pressure and gives each participant equal influence over the group's decision. Participants should not be rushed through this step but should be allowed enough time to give thought to each selection.

STEP 5: Ranking and Displaying Results

Procedure/Leader Responsibilities

1. Each participant should have the n most important items written on the cards in front of them. To help explain the ranking process, let's say the participants were asked to select the 5 most important ideas.
2. Of the possible 5 cards, choose the <u>most</u> important idea, write the number 5 with a circle around it in the lower right hand corner of the card, and set the card aside.

Item #
Identifying Phrase
5

3. From the remaining 4 cards, choose the <u>least</u> important idea write the number 1 with a circle around it in the lower right hand corner of the card, and set the card aside.
4. Repeat the process for the remaining cards.

5. Of the possible 3 cards remaining, choose the most important idea write the number 3 with a circle around it in the lower right hand corner of the card, and set the card aside.
6. From the remaining cards, choose the least important...etc.
7. When ranking is completed, collect and shuffle the cards to prevent rankings from being associated with a particular person. Then tally and display results to the group.
8. Results for each idea should be displayed as follows:

Sum of Rankings / Total Number of Votes

Benefits:

- o Expressing judgments by rank-ordering increases accuracy of judgement.
- o Displaying array of individual ranking clearly highlights areas needing further clarification or discussion.

  Ideally, several items will be highly ranked by all or most of the members of the group.

Ranking allows the participants to express opinions of the relative importance of the ideas. The purpose of ranking one idea at a time is to encourage slow, carefully made decisions.

Once the ideas have been ranked, the results should-be tallied and displayed before the participants. If one or two ideas are ranked noticeably higher and receive a high number of votes, then a consensus has been reached. However, if several ideas receive a high ranking then further clarification and reranking (Step 6) is needed. It is extremely important that a consensus be reached. This will enable group members to leave with the feeling of satisfaction associated with making a decision about an important issue.

STEP 6: Discussion and Re-Ranking (If Necessary)

If no clear consensus exists, that is, if most participants did not vote on the same ideas, further clarification and a re-ranking may be needed.

Procedure/Leader Responsibilities

1. Promote discussion among members of why they did or didn't vote for certain ideas. Clarify any misunderstanding about specific ideas.
2. Repeat Step 5

Benefits:

- Accurate aggregation of group judgments
- Error Reduction
- Provides closure and consensus for meeting

Classical Brainstorming

Brainstorming works best as a group problem solving technique, but it may be modified and used by an individual as well. The idea behind brainstorming is that by generating many ideas your chances are much greater that a problem, project, cause of a problem, or solution to a problem will meet your specific criteria.

Brainstorming can be used anytime it is necessary to generate new ideas. This is a less structured approach than the NGT. It will be necessary when choosing a method for generating ideas that you look at the group of people that you will be dealing with and evaluate their skills and personal characteristics. This is discussed under Possible Criteria for Problem Selection on page 14.

Advantages

- Promotes interaction among participants that can stimulate the thought process.
- Promotes the input of unusual ideas which may stimulate realistic ideas.

Disadvantages

- Idea generation may be controlled by dominant personality.
- Association of idea to individual may develop personal disagreements.

Basic Brainstorming Rules

1. No Criticism or evaluation of ideas is allowed while generating ideas.
2. Freewheeling is encouraged. No idea should be considered ridiculous or inappropriate.
3. Quantity is desirable - The more ideas generated the better the chance of identifying a problem that will meet the considerations stated.

Steps of Brainstorming Session

An example of a typical brainstorming session would proceed as follows:

1. Develop Task Statement.
2. Write the task statement on a board or flip chart and ask that ideas be given one at a time.
3. All the members including the leader participate in generating ideas.

4. All ideas are recorded on a flip chart or board by the leader or an assistant.
5. Members take turns, giving one idea per turn.
6. Ideas are not criticized or evaluated during the initial brainstorming session.
7. Ideas are evaluated following the completion of brainstorming for ideas. Evaluation may include:
   a) Discussing each idea for clarity and understanding.
   b) Combining or eliminating ideas that do not meet criteria (i.e. cost constraint, time constraint, etc.).
   c) Identifying and selecting the best idea by vote or consensus by discussion.

STEP 1: Develop a Task Statement

This step is very much the same as the first step of the NGT. The task statement will focus the group on a specific area, problem, or situation. An example of a task statement may be; "List ideas for improving productivity, effectiveness, and/or efficiency in your work area." Write the task statement on a board or large piece of paper (i.e. flip chart) that will be visible to all members during idea generation.

STEP 2: Generate Ideas

There are two ways that this step can be conducted. The first would be to have the members take turns giving ideas one at a time. In a brainstorming session it's important that the facilitator/leader encourage equal participation from all the members. If the brainstorming session seems to be dominated by a few members and others feel inhibited the leader might try a round robin approach as used in the NGT. This is done by going around to each group member giving him or her a chance to suggest an idea.

If a person does not have an idea he or she can "pass", and the next member is given a turn. As members give their ideas the leader or another individual will record the idea on the flip chart or board. During this step there is no criticism of ideas allowed. Participants should be encouraged to be freewheeling and generate as many ideas as possible. Remember quantity will lead to quality.

STEP 3: Evaluate Ideas

Evaluation includes: identifying best ideas, and selecting the best idea. Evaluate each idea in turn. Discuss each idea so that all of the members are clear on their meaning. Combine ideas for improvement where applicable and eliminate duplicate ideas. Refer back to the previously discussed criteria and constraints and eliminate any ideas that don't meet them. Select the "best" ideas and circle them for easy identification. Rank the identified "best" ideas. This can be done by reaching a consensus through discussion or by a group vote. Be sure that the idea that is chosen meets the criteria and constraints that you have set.

<u>Problem Dimensions</u>

Once you have selected the problem you want to try to improve, it is important to gather as much information about the problem as possible. This will help to identify any gaps in the information. In addition, this exercise will help to determine which data collection technique would be most effective in further quantifying the extent of the problem.

There are at least eight dimensions of problem information to consider. Before trying to solve any problem, the group should gather as much information as possible about these dimensions. This will permit you to develop a perspective on the problem that can be used to generate alternative definitions and can eventually

lead you to a unique and workable solution. The eight dimensions are[1]:

Magnitude. What is the scope of the problem? Compared to other problems the group has dealt with, how big is this problem? What are its boundaries? How widespread is this problem? Very large problems often command more attention and lead to more immediate action than smaller problems.

History. What events led to this problem? How long has it been a problem? Why is it a problem? When did it first come to your attention? Who else, if anyone, has been involved with this problem in the past? Where did the problem begin? The information gathered by taking a historical perspective can often be useful for estimating a problem's magnitude as well as for increasing clarity about the problem's key components.

Location. Where is the problem located? Is this problem linked with other problems? How widespread is this problem? Determining a problem's specific location can greatly increase the overall efficiency of the problem solving process.

Multiple causes. How many different factors contributed to the creation of this problem? If more than one factor contributed to the problem, what was distinctive about the way the factors were combined? Many situations become problems only when certain factors cluster together in a unique way to produce a perception that a problem exists. For example, individuals may not view a situation as a problem until they interact with certain other people.

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[1] Reprinted, by permission of publisher, from Manaaing Group, Creativity a Modular Approach to Problem Solving, by Arthur B. VanGundy, p. 89-90, 431984 AMACOM, A Division of American Management Association, New York.

Threat. To what extent is the problem seen as a threat to some value or resource possessed by the group? How likely is it that this threat will increase or decrease in magnitude? Are individuals more threatened than the group? Has the group experienced similar threats? To some degree, all ill-structured problems convey some amount of threat to the affected persons. When the amount of perceived threat exceeds a group's threshold of tolerance, the group may find that its ability to deal effectively with the problem is severely curtailed.

Time horizon. Does it appear that the problem will have a short or long term effect on the group or other involved individuals? Does the group seem to have a short or a long range perception of this problem? How long will it take to solve this problem? This time horizon of a problem will be an important factor for a group to consider in planning its strategy. Problems that have long-term effects, for example, will necessitate long-term allocations of resources and will affect the ability of a group to deal with other problems.

Complexity. How complex is the problem? How many different elements does it contain? To what extent are these elements interdependent? How do the problem elements interact? Which elements should be treated separately as subproblems? Collecting information about this dimension is crucial to effective problem solving, because changes in one aspect of a problem often will affect other aspects. Most problems can be viewed as systems in which several different components must be dealt with simultaneously.

Time Frame For Solution Development

Throughout the methods improvement process, it will be necessary to set deadlines for the completion of each step. This is

especially important for the solution development and implementation steps. Once the problem has been selected, you should construct a schedule by which you will develop your solution. It does not need to be a detailed schedule, but it should contain any major milestones. If the solution development phase is open-ended, progress will tend to be slower and less directed. There is a tradeoff to be made between allowing enough time to evaluate alternative solutions and too much time so that interest and momentum are lost and no improvement is made in the quality of the solution. An adequate time frame will vary according to the nature and extent of the problem being addressed.

Discussing and proposing change can sometimes lead to tense and anxious situations. At times, you may even find yourself reluctant to pursue certain areas because of the resistance you may encounter from people who do not see the need for change. It is at those times that it is important to be persistent and stick to the schedule. Maintaining your schedule will also convey to management the sense of commitment and urgency you feel about implementing the improvements in the problem area.

Identifying Perceived Causes

Once you have selected the problem or problems that will be addressed you will need to identify the causes contributing to the problem.

It's important at this point that you make sure that the problem. that has been previously identified is a problem and not a cause of another problem. For example, if the problem is stated as "Lack of Supervision" this is not really a problem but instead is the cause of a problem. The problem that should have been identified may be "Too much Rework" or "Poor Quality Work". If you find that this is the case with your particular problem it may be necessary

to reevaluate the results of the Nominal Group Technique or the Brainstorming session.

There are several ways to identify the causes contributing to a problem, all of which are variations on different ways of representing and generating ideas. The three methods of idea generation which are referred to throughout this workshop are:

1) Cause and Effect Analysis
2) Brainstorming
3) Nominal Group Technique

Cause and Effect Analysis

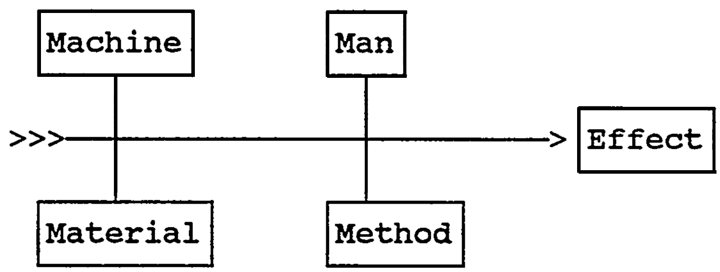
The Characteristic-Factor Diagrams or Fishbone diagram gives the user the opportunity to visualize the problem and its various factors that influence it. By listing general categories of different areas where causes may exist, the individual or group is given a means of stimulating and organizing their thought process.

Four categories frequently used in constructing Fishbone diagrams are Machine, Man Power, Material, and Methods. Other more detailed categories may be used, such as skills, knowledge, procedure, protection, Process Control, and other dependent factors.

Constructing a Fishbone Diagram:

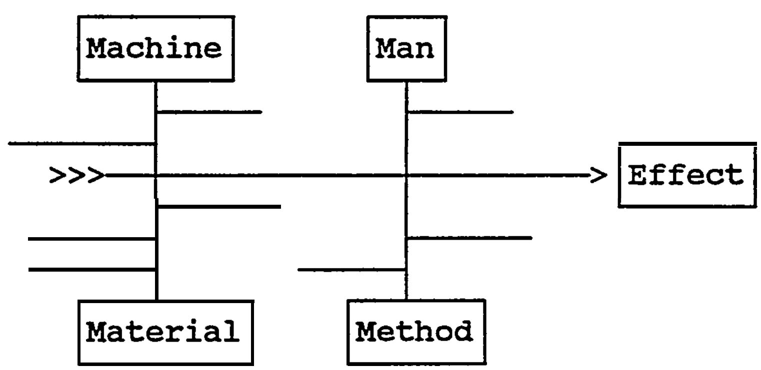
Step 1: Draw a horizontal line with an arrow at the right-hand end and a box in front of it. The effect or problem should be written in the box.

Step 2: Write the major causes (man, material, machine, and method) in boxes placed parallel to and some distance from the main arrow. Connect the boxes to the main arrow.



Sometimes it is possible, or may be necessary, to add more than four major causes (These four will usually be sufficient).

Step 3: List the minor causes on the chart around the major causes which they affect. They are connected by lines to the major causes.



Uses of Cause and Effect Analysis:

1. To recognize important causes.
2. To understand all effects and causes.
3. To compare operational procedures.
4. To find major solutions.
5. To figure out what to do.
6. To improve the process.

When listing causes under the agreed upon categories be sure to list causes contributing to the problem and not solutions to the problem. For example if the problem was "Too much Rework" then a cause must be stated as "Poor Quality Assurance" and not "Improve Quality Assurance". This is a subtle point but it will help keep the people generating the causes on the right track, and not jumping to solutions before the problem has been fully identified.

Brainstorming

Another way of identifying causes relating to a problem would be a brainstorming session in which all possible causes are identified, and listed. This is a less structured approach than the fishbone diagram and may be more difficult to stimulate the thought process. It will be necessary when choosing a method for generating ideas that you look at the group of people that you will be dealing with and evaluate their skills and personal characteristics. Brainstorming was discussed in detail in Section II.

Nominal Group Technique

The Nominal Group Technique (NGT) was discussed in detail in Section II. The NGT can be used to identify causes, but again, this process requires a participant that is a bit more dynamic and

has definite ideas concerning the causes contributing to the problem. Participants will receive almost no stimulation from other group members because of the silent idea generation.

III. DATA COLLECTION TECHNIQUES

The next step in the methods improvement process, after selecting the problem to be studied and defining the causes, is to record all the facts relating to the existing method. The success of the whole procedure depends on the accuracy with which the facts are recorded, because they will provide the basis for both the critical examination and the development of the improved method. It is therefore essential that the record be clear and concise.

The usual way of recording facts is to write them down. Unfortunately, this method is not suited to the recording of the complicated processes which are so common in shipbuilding. This is particularly so when an exact record is required of the details of a process or operation. To describe exactly everything that is done in even a very simple job which takes perhaps only a few minutes to perform would probably result in several pages of closely written script. This would require careful study before someone reading it could be quite sure that he had grasped all the detail.

To overcome this difficulty, other techniques or "tools" of recording have been developed so that detailed information may be recorded precisely and at the same time in standard form, in order that it may be readily understood by all. The causes of the problem should be used to define the focus of the study to be performed. It is important to remember that the information collected must be relevant to the problem so that it can be used in the development of solutions to the problem.

The data collection techniques to be discussed at length are work sampling, process charts, surveys, and self logging.

Work Sampling

Work sampling is based upon the laws of probability. A random sample from a large group tends to have the same pattern of distribution as the large group. If the sample is large enough, the characteristics of the sample will differ very little from the characteristics of the group. The percent of distribution of various elements, as they occur during random obsenations, tends to equal the percentage of the time spent on these various activities that would be found by continuous observation.

The accuracy of the work sampling study is determined by the number of observations taken. A greater number of observations provides a higher degree of accuracy. Thus, the accuracy of the results is a function of the number of observations taken over a sufficiently long study. The number of times a worker or machine is observed working, idle, or in any other state tends to equal the percentage of time in that state. This is true whether the occurrences are very short or extretiely long, regular or irregular, many or few.

Advantages

Work sampling is an inexpensive means of getting a fairly accurate measure of machine downtime, manpower utilization, crane wait, clean-up, or an overview of a job. It helps identify problems, opportunities for work simplification, need for training, etc.. It can easily be tied into the regular work routine, and is easily learned.

How Does it Work

Example: Gallup Poll, Throwing Dice or Tossing a Coin

Just as the Gallup Poll takes a random sample of the registered voters in the state or country to predict how the public will vote, a work sampling can take a random sample to estimate machine downtime. Pollsters wouldn't look at just one state to find out how the country is voting and they wouldn't look at a single city to find out how the state is voting. You cannot look at the machinery space on a ship to estimate the performance of the whole ship. The idea is to work like the polls in being able to show results with just a small percentage of the total measured.

When a coin is tossed, the result is one of two possibilities, heads or tails. The law of chance says there should be 50 heads and 50 tails in 100 tosses of a coin. That is the ratio of the average possibility. It does not mean it will come out 50-50 on the button every 100 tosses. The score may be 60-40, 45-55, or some other ratio. But it has been proved that the law becomes increasingly accurate as the number of tosses increases. The percentage of possible error decreases.

Another example is throwing dice. When dice are thrown it is a little more complex than coin tossing because one throw of two dice has 36 possible results, instead of two. Thirty-six throws will tend to produce one 2, two 3s, three 4s, four 5s, five 6s, six 7s, five 8s, and so on. Each series of 36 throws will not duplicate on the pattern exactly. But the results get closer to the pattern as the number of 36 throws is increased.

How to Prepare For a Work Sampling Study

Importance of communication in initiating a work sampling.

So often in starting work sampling programs, management takes the general attitude that this is its prerogative and that it is not necessary to relate to the union, or to those to be observed, just what the technique is all about. If union members are to be observed, then it is advised that a presentation be made to the union representatives. People being observed in a work sampling should be informed of what will be done, who will be doing the study, what will be observed in the study, when the study will be done, why the study will be done, and how the information will be used. One of the greatest needs today is to improve communication in order to gain acceptance of the programs from the personnel involved. In short, it's necessary to "talk to the guys" more.

The best way to sell work sampling is in the explanation "why does work sampling work?" By all means, use examples, such as tossing a coin or throwing dice. They are more effective than a long talk in getting the idea across.

I Define The Study

- o Determine exactly what information is required.
  - * State the main objective
    - Establish rates
    - Locate and Identify delays
    - Determine equipment utilization
- o Make a preliminary survey.
  - * Observe the operation for a day to get a list of operation elements
- o Define all the possible primary causes of the problem.

II Preliminary Estimate

The preliminary estimate is simply a guess of the percent occurrence of the condition to be measured. This is used to determine beforehand the approximate number of observations that will be required.

The estimate can be based on an intelligent guess using past performance, or in cases of doubt, a series of fifty to one hundred observations can be used to calculate a rough estimate.

It might be well to point out here that one person or one machine observed is equivalent to one observation. If we were to observe a group containing three people or three machines, then each time we record the activity of the group we are making three observations.

Observation	Random Time*	Observations	Machine Operating	Machine Idle
1	8:20	4	4	0
2	8:55	4	2	2
3	10:30	4	3	1
4	11:05	4	0	4
5	11:25	4	3	1
6	12:55	4	4	0
7	1:00	4	0	4
8	1:05	4	2	2
9	1:55	4	2	2
10	2:45	4	4	0
11	2:50	4	3	1
12	3:10	4	4	0
13	3:25	4	0	4
Totals		52	31	21

Figure 1

Figure 1 is a sample tally sheet of a preliminary study of a group of four machines. To estimate the percent running time divide 31/52 = 0.596. This, then, is the preliminary estimate.

These observations can be used in the analysis of this operation and need not be discarded.

III PLAN

In order to plan the approach, there are two important subjects to cover:

1. How many obsenations to make
2. How to make them

How many observations to make depends on two variables: the percent occurrence of the condition you want to measure and the deviation from this percent occurrence you will be willing to accept. The percent of occurrence will be decided upon by one of the two methods discussed in Step II. The percent deviation from this percentage will depend upon the use you will make of the results. For general use, we can use the same reasoning that we do in time study, that is a deviation from the "true" answer of ±5 percent would be entirely satisfactory.

The formula most often used in the application of work sampling is:

$$N = \frac{4(1 - P)}{d^2 P}$$

where:

N = Number of observations necessary

P = Average percent occurrence of condition being observed (expressed as a decimal - example 60 percent would be .6)

d = Deviation from P that will be satisfactory (expressed as a percentage - example ±5 ercent would be .05)

This formula is commonly referred to as the 95 percent confidence level. This means that 95 times out of 100 you can be sure that

your answer will be within the precision you have prescribed in your choice of "d" in the formula. It is not necessary to use the formula to derive the necessary number of observations - the following alignment chart (Chart 1) can be used to determine the answer directly. Note that in this chart the middle column is called precision interval - this is the acceptable deviation multiplied by the percent of occurrence (d x P). This is the absolute error that is possible in the result.

CHART 1 - NUMBER OF OBSERVATIONS needed to get the precision you want is given by this chart. Here's how to use the alignment chart:

1. Estimate (Preliminary estimate or intelligent guess) the average percent of the work element you want to measure.

2. Decide what precision you want (for example, ±5 percent).

3. Multiply your estimate of the average percent of the element by the selected precision to get the "precision interval".

4. Draw a straight line from the average percent, through the precision interval, to the number-of-observations line.

Example: To get ±5 percent precision on work that's estimated to take 80 percent of workers time, you'll find that 400 observations are needed, according to this chart.

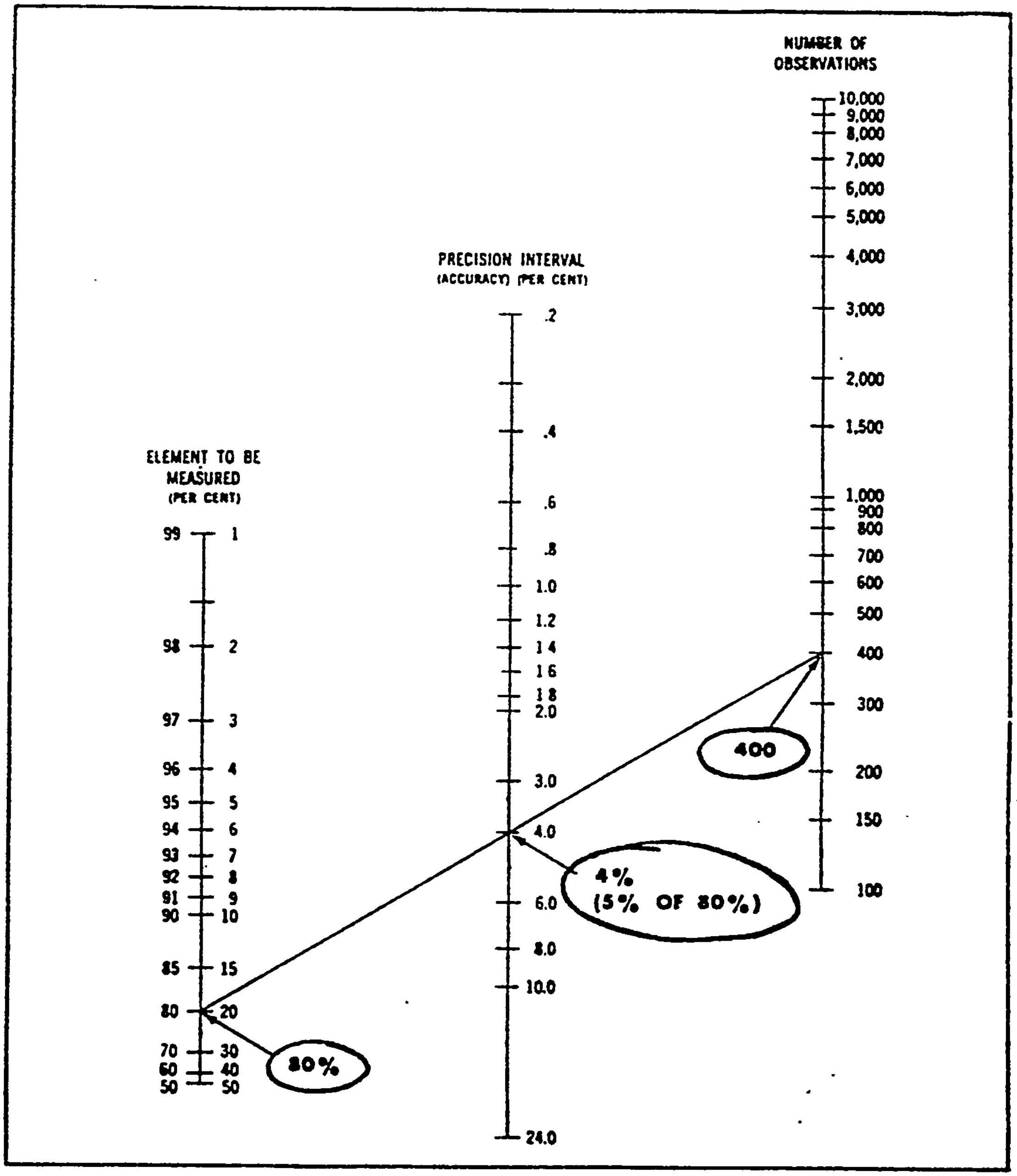


Chart I
NUMBER OF OBSERVATIONS

Once you have decided the required number of observations, it is necessary to decide how to make them before you have completed Step III.

Selecting Frequency of Observations

a) Nature of Operation Being Observed

1) If it is a short-cycle repetitive operation where the activities being observed occur frequently, the observations can be spread out over time.

2) If it is a non-repetitive operation or one where the activities being observed occur infrequently, it is better to make more observations in a day.

b) Physical Limits

1) If there is just one observer and a long route is necessary, the observer will be able to make relatively few observations in a day.

Knowing the nature of the operation being observed and the physical limits of the observer(s) you can determine how many readings can be made per trip, and how many trips will need to be made per day. From this information you will be able to determine the number of days the study will take to complete.

The next point we should consider is that work sampling is most accurate when your observations are made at random. This will assure you that the results will be based strictly on chance. In deciding the frequency of the observations, two points have to be considered - how soon you need the answer and how long it takes to make an observation. These two factors will determine how many observations you can make per day. For example, if the area you are sampling is so large that it takes 30 minutes to complete one observation trip, it is obvious that you cannot make more than 16 trips in a normal working day.

Chart 2

TABLE OF RANDOM OBSERVATION TIMES FOR WORK SAMPLING

Read up, down, across, diagonally, **or at** randon In both tables to avoid a biased sample.

Hours: **CA=A.M., P= P.M.)**

Dlsregard hews not in shift concerned

2P	9A	8P	7A	6P	12P	5A	7A	12A	11A	10A	8P
11A	12P	12A	3A	4P	5A	9A	7A	1P	10P	8A	3P
10p	7P	4P	3A	11P	3P	6P	9A	12A	2A	11A	4A
9P	3P	2A	10A	10P	1P	6A	1A	5P	5A	5P	8P
6A	6P	8A	1P	11P	9A	IOP	2P	8A	9P	6A	5P
8A	3P	2A	5P	12P	6P	12A	9P	3A	4A	9P	10A

Minutes

47	23	48	Z6	22	35	31	27	47	43	41	42
23	00	36	46	27	50	6	00	21	50	42	56
35	22	18	37	33	56	18	53	6	59	27	44
39	19	9	21	13	44	8	57	17	2	17	18
15	16	12	4	1	17	13	43	32	26	24	12
39	3	38	21	36	29	27	9	53	54	59	34
16	23	53	5	43	40	23	22	8	26	42	21
52	15	40	2	28	56	28	13	15	30	26	3
56	58	2	10	22	43	35	20	58	33	18	47
21	57	35	47	39	20	25	8	56	54	6	4

There are many ways that you can be assured of randomness by choosing your observation schedule completely by chance. A better and quicker way would be to use one of the following two charts (Chart 2 and 3) . Reference may also be made to tables of random numbers available in most statistics books. In addition, you can introduce even more randomness by having more than one route tc follow when making your observations in the area being studied.

The following table of Random Sampling Times (Chart 3) was devised from a table of random numbers. This table lists twenty-five chronological random sampling times for each of twenty-one eight-hour work days. The figures which appear in the columns are easily translated into actual clock times. They represent the hours and minutes after the start of the work shift. For example, assume that the working period begins at 8:00 a.m. then the first sampling

Chart 3

TABLE OF RANDOM SAMPLING TIMES

1	2	3	4	5	6	7
(19)0:05	0:20	0:10	0:15	(18)0:05	(23)0:10	0:15
0:20	(18)0:50	(16)0:35	0:25	0:25	0:25	(21)0:20
0:55	(24)1:20	0:55	(16)1:20	0:45	(21)0:30	(16)0:35
(22)1:10	(21)1:45	(24)1:00	1:40	1:05	0:40	(15)0:50
(20)1:20	1:55	1:10	1:55	(21)1:50	1:10	1:00
(24)1:35	2:00	1:45	2:00	(20)2:10	1:20	1:25
2:30	2:30	(19)2:00	2:30	2:20	1:30	(23)1:40
3:05	2:40	2:05	(15)2:50	2:30	2:25	(22)1:50
(16)3:10	3:10	(21)2:45	3:10	(19)2:35	2:35	1:55
(25)3:15	(23)3:30	2:50	(18)3:30	(17)2:50	2:40	2:45
3:25	(22)3:40	(22)3:00	3:45	(23)3:00	(24)2:55	(25)3:05
(21)3:45	3:50	3:20	3:50	(16)3:10	(19)3:05	3:50
4:00	4:05	3:30	4:30	3:40	3:15	(19)4:00
4:10	(16)4:15	(20)4:40	(20)4:40	(24)3:45	(17)3:25	4:25
(18)4:35	(17)4:20	4:45	5:10	(15)4:30	(15)3:30	(18)4:45
4:55	(19)4:25	4:55	5:20	5:00	3:40	(20)5:00
5:00	4:30	5:00	(17)5:30	5:45	(16)3:50	5:10
(15)5:05	(15)4:35	(18)5:55	(25)5:45	(22)5:50	4:00	(24)5:15
(17)5:35	5:20	(25)6:00	(19)5:50	5:55	4:15	6:20
5:55	5:35	6:05	(21)6:15	6:00	4:25	6:25
(23)6:20	6:15	(23)6:35	6:20	6:35	(18)4:35	6:50
6:45	(20)6:40	(15)6:40	(24)6:25	6:45	(22)5:40	6:55
6:50	(25)6:45	7:10	6:50	(25)7:00	(25)6:45	7:15
7:10	7:10	7:35	7:30	7:45	6:55	7:40
7:25	7:35	(17)7:50	7:55	7:55	(20)7:35	(17)7:45

8	9	10	11	12	13	14
(17)0:05	0:25	0:05	(25)0:05	(22)0:10	(25)0:10	0:10
(18)0:20	0:30	0:15	(18)0:15	0:20	0:15	(17)0:15
(15)1:05	0:40	0:40	0:20	0:30	1:10	0:20
1:25	(24)0:45	1:30	0:25	1:30	1:25	(22)0:25
1:30	1:00	1:45	0.55	(19)1:45	(21)1:30	(24)0:50
2:05	(18)1:10	(21)2:20	1:20	1:50	1:40	(18)1:25
2:25	(17)1:25	2:25	1:35	2:25	1:45	1:35
(24)2:40	1:40	(22)3:10	1:55	(25)2:35	(16)2:05	(23)2:10
(16)3:00	2:15	(20)3:40	(17)2:10	(17)3:05	2:40	(20)2:15
3:20	2:20	(15)3:50	2:30	3:10	(19)2:45	2:40
4:25	2:30	4:15	2:45	3:50	2:55	2:55
4:45	(15)2:40	(24)4:20	(21)2:50	3:55	(22)3:40	3:35
4:50	2:45	4:30	(22)2:55	4:05	3:45	(21)3:40
(25)4:55	(21)3:05	(25)4:40	(15)3:00	4:10	(18)3:50	4:35
5:05	(16)3:30	4:55	(16)3:30	4:50	(24)4:05	(16)4:45
5:15	3:35	5:00	3:35	(21)5:10	(20)4:25	(19)5:05
5:50	4:00	5:15	(23 3:45	(16)5:25	4:55	5:10
5:55	4:15	(19)5:20	4:05	(15)5:30	5:15	5:50
(22)6:00	(23)4:50	5:25	5:00	(24)6:00	5:45	6:05
(20)6:10	(20)5:45	(23)6:05	(19)5:40	6:05	(15)6:20	6:20
(19)6:20	(22)5:50	(17)6:45	(24)5:50	6:15	6:25	7:05
6:35	6:25	(18)7:15	6:25	6:30	(17)6:30	7:10
(23)7:10	(19)6:50	7:25	7:20	(18)6:50	6:35	7:20
7:15	(25)7:05	7:35	7:40	(23)6:55	(23)7:35	(25)7:50
(21)7:30	7:30	(16)7:55	(20)7:50	(20)7:25	7:50	(15)7:55

(Cont'd on next page)

Chart 3 (Cont'd)

15	16	17	18	19	20	21
0:50	0:15	0:05	1:00	0:05	(20)0:25	0:25
1:10	(23)0:35	(17)0:40	(16)1:10	0:55	0:55	(17)0:35
1:20	(20)0:45	(25)0:50	1:35	(16)1:00	1:30	1:00
(15)1:25	0:55	(23)1:10	(21)1:50	(24)1:25	2:00	1:05
1:30	1:00	1:40	1:55	1:40	2:50	1:10
(20)2:00	(19)1:05	1:50	2:10	1:45	(21)3:10	(20)1:50
2:20	1:25	1:55	2:20	(18)1:55	3:15	(18)2:40
(24)2:40	2:20	(16)2:00	(23)3:00	2:05	(24)3:25	(24)2:55
2:45	(21)2:25	(24)2:40	3:05	(17)2:40	(19)3:35	3:10
2:50	2:35	(21)2:45	3:15	(25)2:50	(22)3:40	(25)3:15
3:10	(17)2:40	(15)3:15	3:50	(21)3:15	3:45	3:45
(25)3:35	(25)3:05	4:20	4:30	3:55	4:00	3:55
(16)4:00	(15)3:10	4:30	(20)4:50	4:00	(17)4:10	4:15
(21)4:25	3:15	4:50	4:55	4:05	5:10	4:25
5:00	3:30	(19)5:00	(24)5:35	4:15	(25)5:40	4:45
5:10	(16)3:40	5:05	(15)5:40	(23)4:20	5:45	(23)5:00
5:20	4:05	5:20	5:45	4:45	5:55	5:25
(17)5:25	(18)4:10	6:05	5:50	5:15	6:20	(19)5:30
(23)5:35	4:35	(18)6:10	(18)6:15	(22)5:50	(16)6:30	6:10
(19)5:55	5:10	6:40	(19)6:20	6:10	6:40	6:45
6:00	5:20	6:50	(17)6:35	(20)6:35	(18)7:00	(15)7:10
6:15	5:50	(20)6:55	(25)6:45	(19)6:45	7:05	(16)7:30
(22)6:55	(22)6:00	7:00	7:10	6:55	7:15	(22)7:40
(18)7:25	6:15	(22)7:35	(22)7:20	(15)7:00	(23)7:35	7:45
7:50	(24)7:50	7:55	7:55	7:50	(15)7:55	(21)7:50

time of the first column, which is 0:05, would be interpreted as 8:05 a.m. Similarly, the last sampling time of the same column, 7:25, would represent 8:00 + 7:25 = 15:25 or 3:25 p.m.

By the proper use of this table, a list of random times of any desired length can be obtained. If twenty-five or less sampling times are planned for a day, one column will be sufficient. After the column selected has been translated into clock times, those times falling in scheduled rest and lunch periods are eliminated.

If the number of sampling times remaining is greater than planned, the numbers in parentheses to the left of certain times are used to reduce the list of the desired number. These auxiliary numbers indicate the order in which the times were originally selected from the random number table. In order to maintain the randomness of

the list, numbers should be eliminated from the list in reverse order to their selection. Thus, if only twenty sampling trips were planned from Column 1, times designated as (25), (24), (23), (22), and (21); 3:15, 1:35, 6:20, 1:10, and 3:45 respectively, would be eliminated.

Should more than twenty-five trips be desired in any one day, twc or more columns may be combined and duplications eliminated. The same procedure as outlined above can then be applied to achieve the desired number of sampling trips. Different columns or combinations of columns should be used for planning the sampling trips for different days.

IV Design an Observation Form

What is an Observation?

An observation is a description of what is being done. It is a snapshot of an activity that is clearly and immediately identifiable. An observation is not of a worker, but of an activity taking place at that instant.

Group Consensus on Terminology

It is very important that those involved in the work sampling agree to the categories that will be used and the naming of the categories on the observation form.

Preparing a Form

The form used for recording the observations made during the course of a work sampling study must be individually designed in each case. The design will depend upon the number of work stations or people to be observed and the

classification of the activities upon which it is desired to obtain data. An example of an observation form can be seen on the following page (page 51).

V Carry Out Plan

At this point you are ready to go on with the sampling. One further point is worthy of discussion. Most texts devote considerable space to a discussion of the mechanics of making a work sample. In the interest of brevity, only the most important points will be covered here.

1. All observations should be instantaneous - at the instant the observer reaches the point of observation, he must record what is happening (he should not wait to see if the man is getting ready to start working).
2. Adhere to the sequence of random times that have been designated..
3. If designated routes have been given be sure to stick tc your assigned route when making observations.

The results of the observations should be calculated daily. Also, a running record should be kept of the total average percentage adding each day’s result to all previous totals. This will enable you to revise the necessary number of observations (by again using the alignment chart) if there is a significant difference in the actual percent of occurrence and your preliminary estimate.

VI Check Data For Control

There are two schools of thought on what is necessary to assure that your results are statistically sound. The simplest is by merely plotting the cumulative average until the curve levels off. However, this approach may be inadequate where a greater degree of

Name: ____________________

Date: ____________________

Approx. Start Time: __________

Location: ____________________

____

Start Time: __________

Finish Time: __________

WORK SAMPLING STUDY

CATEGORIES	OBSERVATION #										COMMENTS
	1	2	3	4	5	6	7	8	9	10	
Misc. Value Added											
Bending											
Drilling											
Sawing											
Misc. Semi Value Added											
Set-up Bender											
Reading Prints											
Receiving Instructions											
Paperwork											
Cleaning Up Work Site											
Retrieving Material											
Waiting for Equipment											
Getting Tools											
Misc. No Value											
Visiting											
Personal											
	1	2	3	4	5	6	7	8	9	10	

accuracy is required. Before you can say that your study is statistically sound, you should look at the difference between each days percent of occurrence and the total study average to ascertain that each days results are within the daily allowable variation. This is a control tool and should not be confused with the original acceptable percent deviation because daily deviations may exceed the original estimate and still be statistically correct. The following alignment chart (Chart 4) can be used to determine the allowable variation of the percent occurrence for the particular element observed. Please note that the right-hand line is expressed in observations per day. The example given points out that information falling outside the limits should be discarded from the study because the final average percent of occurrence must come from observation of similar work conditions to be meaningful.

To use Chart 4:

1. Mark on left-hand line the observed percentage of the element measured.

2. On the right-hand line, mark the total number of observations made each day of the study.

3. Connect the two points by a straight line.

4. Read the allowable variation (control limits) on the center line.

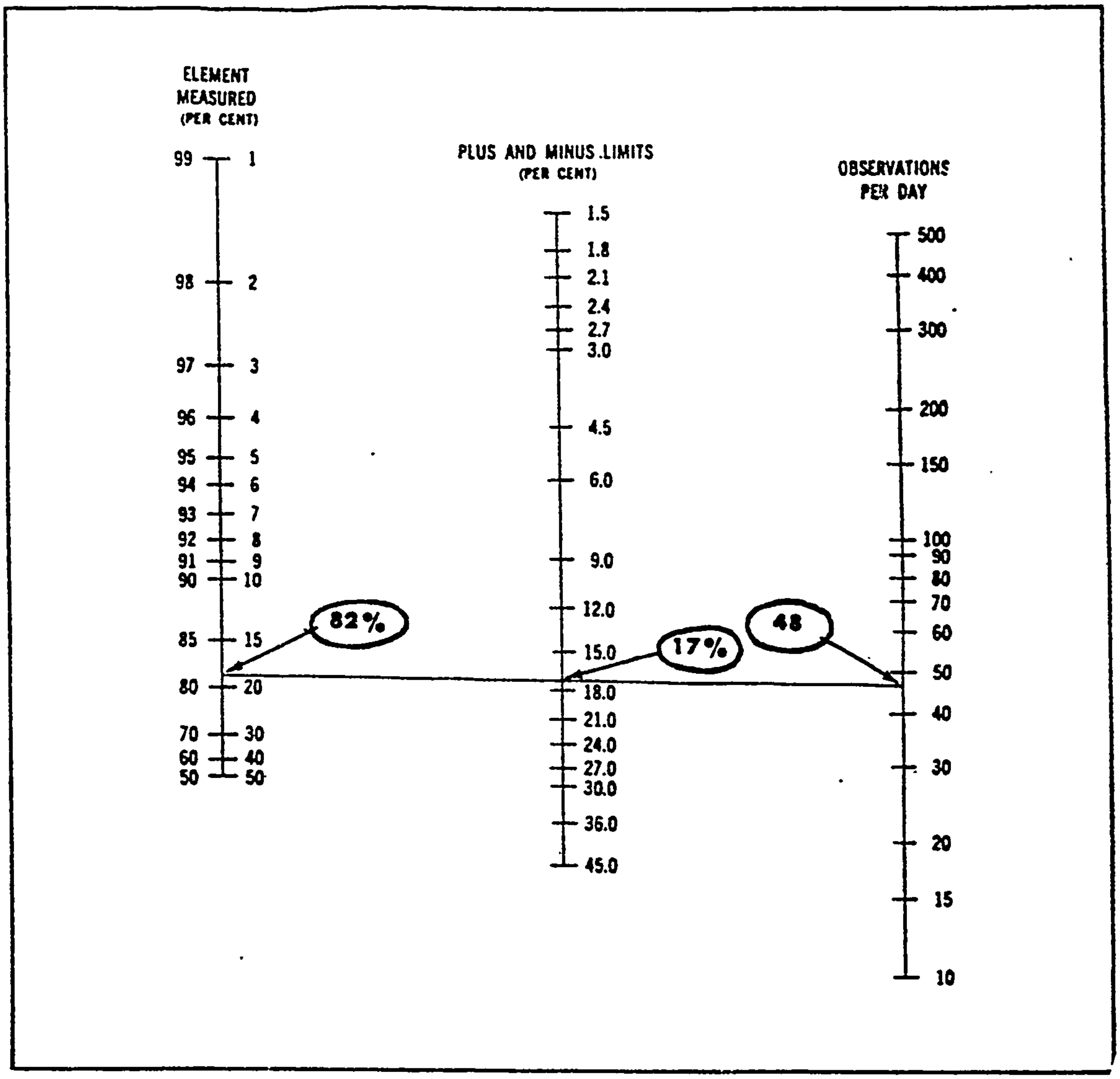


Chart 4 - CONTROL LIMITS for your Work
Sampling study results are found in this chart.

Example: If the average handling activity during a ten-day study is 82 percent, and the number of daily observations 48, then each day's percent activity should be between 65 percent and 99 percent (82 ± 17 percent) to be statistically stable. Find the cause for any day that is outside limits. Data connected with that cause should be thrown out in order to achieve the statistical reliability you're looking for.

VII Check Final Results

After completing Step VI, the data will be in statistical control and then, <u>and only then,</u> can you check the final deviation by use of the original alignment chart used in Step III on page 43. By lining up the final percent of occurrence and the actual number of observations, you can read the precision interval on the middle scale. Divide this by the percent of occurrence and this will tell you the actual deviation (d). In other words, you can be 95 percent certain that your answer is the percent of occurrence plus or minus this resulting deviation. If this doesn't offer the degree of accuracy required, more observations will be necessary.

VIII Summarize Results

Upon the completion of the work sampling it is necessary to summarize the study. This will be helpful not only to you so that you can see how items compare, but will be helpful as a reference when presenting proposed methods improvements. Your results should be broken down into several different comparisons such as category, day of the week, time of day, trade, equipment, etc.. Using the data that has been collected and your graphical representations you can clearly indicate the primary causes of the problem identified in the previous section.

It is very important to represent your data graphically not only to summarize your results but also to keep a daily indication of how your study is progressing and potential problems that may be occurring within the study. Appendix A gives an explanation of graphical data representation which may be helpful when plotting the data’ collected from your study. Be sure to plot the data daily.

Process Charts

"A process chart is a schematic or tabular representation of the sequence of all relevant actions or events, operations, transportation, inspection, delays, storage - occurring during a process or procedure," (Maynard, 1971). The intent of the process chart is to provide a graphic representation of a process so that present and proposed methods can be compared visually in chart form .

The purpose of a process chart is to provide the analyst with a tool for studying or analyzing an operation or sequence of operations. The preparation of a process chart is not a solution in itself. It simply provides a compact picture that may point out situations which can be corrected, improved, or eliminated. In addition, process charts are excellent tools for presenting current and proposed processes to management.

Types of Process Charts

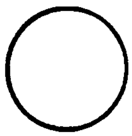
The Flow Process Chart tracks five activities: Operations, Transportation, Inspections, Delays and Storage. This chart can be used to analyze the sequence of operations on a particular part or component or tasks a person performs.

The Operation Process Chart only addresses the introduction of material into the production cycle, and the sequence of operations and inspections subsequently performed on it. This chart provides an excellent way to quickly understand the current process.

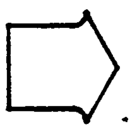
Process Chart Activities

The five main activities have been assigned standard symbols sc that process charts would be universally understandable.

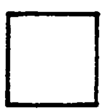
Activities Defined:



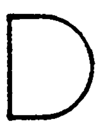
Operation. An operation occurs when an object is intentionally changed in any of its physical or chemical characteristics, is assembled or disassembled from another object, or is arranged or prepared for another operation, transportation, inspection, or storage. An operation also occurs when information is given or received or when planning or calculating takes place. (Symbol: Circle).



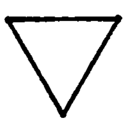
Transportation. A transportation occurs when an object is moved or a person moves from one location to another, except when such movement is part of the operation or is caused by the operator at the work station. (symbol: Arrow) .



Inspection. An inspection occurs when an object is examined for identification or is verified for quality or quantity in any of its characteristics. (symbol : Square) .



Delay. A delay occurs when an object or person waits for the next planned action. (Symbol: D) .



Storage. A storage occurs when an object is kept and protected against unauthorized removal. (Symbol: Inverted Triangle).

Flow Process Chart

The flow process chart is defined as, "A graphic representation of the sequences of all operations, transportation, inspections, delays,and storage occurring during a process or procedure, and

includes information considered desirable for analysis such as time required and distance moved. "

The flow process chart is further subdivided into two types. The material-type which presents the process in terms of events which occur to the material, and the man-type which presents the process in terms of the activities of a person. The material type chart is more useful for a bird's-eye view of production operations while the man type chart is better for maintenance or service operations.

Using a standardized form such as the one on the following page (page 58), the data required are obvious. It is important to actually observe the process when charting and not chart from memory.

Here are some points to keep in mind when making a flow process chart:

1) Time and distance should be shown for all major steps
2) Everything that happens at one work station during an operation is listed on the same line
3) Only important delays should be listed
4) Connect symbols for each item

Total the number of each type of activity and the amount of time spent on each type of activity. Operations have the highest value--added so, naturally, you want those totals to be the highest. A flow process chart can be developed for any proposed or improved methods as well.

FLOW PROCESS CHART

SUBJECT ______________________________ DATE ____________

CHART BEGINS ______________________________

CHART ENDS ______________________________

SYMBOLS	DESCRIPTION	REF.	DISTANCE MOVED IN FEET	UNIT OPER TIME IN HOURS	UNIT TRANS TIME IN HOURS	UNIT INSPECT TIME IN HOURS	DELAY TIME IN HOURS	STORAGE TIME IN HOURS
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
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○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								
○ ⇨ D □ ▽								

Analysis

After the chart has been prepared, it is important to have a questioning attitude when evaluating each event. "why" is the most important question and should be asked repeatedly and applied to each of the other questions: What, Where, When, who, and How as follows:

What should be done? Change activity?	why should it be done? Eliminate unnecessary activity?
Where should it be done? Change sequence?	why should it be done there? Combine?
When should it be done? Change sequence?	why should it done then? Combine?
who should do it? Eliminate?	why should he/she do it? Change sequence?
How should it be done? New process?	why should it be done that way? Change method?

ODeration Process Charts

An operation process chart is a graphic representation of the points at which materials are introduced into the process, and of the sequence of inspections and all operations except those involved in material handling. It includes information considered desirable for analysis such as time required and location.

Two symbols are used in operation process charts. These symbols are ○ (Circle) which denotes an operation and □ (square)

which denotes an inspection.

The order in which material is introduced to a process and the order of operations and inspections in the process is depicted by horizontal and vertical lines with the appropriate headings and symbols . The major components are shown to the far right with other components to the left, feeding into it. Horizontal lines represent material, purchased items, items assembled in the plant, items completely manufactured in the plant, or any one of the many variations of these situations. Vertical lines represent the flow of the process. These lines lead to and from the standard process chart symbols for operations and inspections. The inspections and operations are charted in chronological order. Due to the many variations in operation processes, an operation process chart is commonly prepared on a blank sheet of paper of a convenient size.

Analysis

Once you have completed the operations process chart, there are only four major considerations: M&erials, Operations, Inspections and Time (Maynard, 1971) . You should examine each activity and determine how or if it can be improved.

Materials: Review each for function, reliability, service, cost .

Operations: Review each for alternative method, alternative tools, and alternative equipment.

Can Operations be:
- Eliminated?
- Combined?
- Changed?
- Simplified?

Inspections: Review each for quality level and replacement with in-process sampling techniques.

Time Values: Review each in terms of alternative methods, alternative tooling, use of special equipment, and use of subcontractors.

Self Logging

Self logging is a data collection technique in which a person records the time required to perform various tasks. The self logging should be done by several people performing similar tasks and should be done for long enough periods to see trends develop. All workers should fill out a standardized self logging form throughout the day as they perform various tasks. Extra space should be left on the form for workers to include additional responsibilities and the amount of time they require.

All results of the self logging should be compiled and the average times spent on various tasks should be calculated. Questions need to be asked as to whether an inordinate amount of time is spent on certain tasks. Self logging is especially useful when evaluating the responsibilities associated with a specific job. It is helpful to have a clear and prioritized job description for a position if evaluating how much time is spent on the tasks required of that position.

Advantages

There are several advantages to doing self logging:

- Requires little time from the data collector.
- May enable more data to be collected in shorter period of time.

- Cost less than a time study with data collector observing workers.

Disadvantages

There are a couple of disadvantages to self logging:

- Not accurate measure if only one worker is being observed.
- Requires cooperation of worker being obsened. This is difficult because you first need to convince workers that results will not be used against them.

This last disadvantage is particularly important. Before a self logging can be done with a group of workers, they must first be assured that the results will be used to help them. The amount of trust that is present will determine the honesty of the responses on the self logging forms.

<u>Surveys</u>

Surveys are a quick and relatively simple way to gather needed information. They can be formal, written questionnaires or less formal and completed in an interview format. Surveys are useful for gathering general information about the nature or extent of a particular problem. However, for specific numerical data regarding a problem, a more structured or scientific means of gathering information may be required.

Some of the advantages of surveys are:

- Easy to have the same questions answered by many people.
- Method of compiling varying attitudes and opinions regarding a specific problem or situation.
- Method of soliciting ideas from many people with varying perspectives.

There are a few disadvantages to conducting surveys in an interview format. They are:

- Interviews need to be conducted by a neutral person if honest responses are to be elicited.
- The interviewer needs some understanding of the problem or topic and its terminology if he is to interpret the responses and ask additional questions for clarification.
- Interviews can be very time consuming, especially when there are many to be conducted.
- There can be a large range in the quality of information gathered, particularly if there is more than one interviewer.

When developing a survey, it is essential to consider the following factors:

- What information do you want to obtain?
- Is it specific or general information?
- Who has this information? More than one person or group?
- What is their perspective? What are their concerns? If questioning more than one person or group, how do their perspectives or concerns differ?

There are several important issues to bear in mind when conducting a survey. They are:

- In order for respondents to feel comfortable, it is essential to inform them of the purpose of the survey and how the information will be used. Otherwise, surveys may be completed with less than honest responses or may not be completed at all.
- If the problem being addressed is a controversial or sensitive one, anonymous written surveys may be required.

This will be true especially if there is to be harsh criticism of the way in which the problem is currently handled.

- o All questions must be clear and unambiguous. If trade jargon or terminology is to be used in the survey, it must be clearly understood by all respondents.
- o Questions should be objective and unopinionated. They should not be phrased in a manner that predisposes certain responses.
- o Include in the survey a section for respondents to make suggestions as to how the problem should be handled. Most people appreciate being asked for their suggestions when they have an informed opinion about a particular problem.
- o It is essential to bear in mind the unique perspectives of the respondents. Consider their perspectives and concerns and temper your evaluation of their responses accordingly.

Validating Data Collected

No matter what data collection technique is used, the results must be evaluated according to a set of expectations. These expectations are influenced to a certain extent by the causes you identified. You expect the data to confirm your assumptions of the causes of a particular problem. However, it is difficult to have any confidence in the data collected if it is not thoroughly evaluated. The most fundamental questions to ask are:

- 0 Did the data verify the existence of the problem as expected?
- o Do the results make sense?

Not only should you question the validity of the data after all of it is collected, but you should question it throughout the data collection process, particularly with Work Sampling and Self Logging. You should not wait until all the data is collected to chart or graph it. If the data does not meet expected results, you want to know before it has all been collected.

If data does not meet expected results, here are some questions you should ask:

1) Was the data collection technique properly applied?
2) Was enough data collected to see a trend develop clearly?
3) Were perceived causes correctly identified?
4) Were expectations unrealistic? Unreasonable?
5) Was problem correctly defined initially?

Even if the data does meet expectations, you should ask yourself if there was any bias in the application of the data collection technique that influenced the results.

Here are some hints for validating the results of each of the data collection techniques:

Work Sampling. To validate the data collected, it is important to use Chart 4 (Alignment Chart) to determine your accuracy. Plotting the data daily should also give a clear indication of any trends developing and when you have collected enough data. Work Sampling relies on your common sense and experience. When results do not meet expectations, it is up to you to determine whether the results or expectations were incorrect.

Process Charts. Observe the process more than once and with different operators or machines, if possible. If the results

are inconsistent, find out what caused the difference.

Self Logging. Have more than one person in the same position or title log their activities for several days until a clear trend develops. If there are substantial differences in results, find out why.

Surveys. Distribute surveys to or conduct interviews with as many people as possible that have relevant knowledge of the subject. It is important that those evaluating the responses have enough knowledge to distinguish between differing perspectives and between honest and not-so-honest responses.

Data Collection Summary

The proper application of one of the data collection techniques involves 5 steps:

1) Constructing the study
2) Conducting the study
3) Compiling, charting, and/or graphing the data
4) Validating the data
5) Analyzing and interpreting the data

Listing these steps separately does not imply that these steps are to be performed separately. On the contrary, the last four steps should occur at the same time, no matter which technique is used. After the above steps are completed, you should have identified and quantified the primary causes of the problem which will be used in identifying a solution.

IV. DESIRED OUTCOMES

The statement of desired outcomes is a critical component of the problem solving process. Too often plans are set in motion without having clearly thought through what the plan should accomplish. In Albert Einstein’s words, Imperfection of means and confusion of ends seems to characterize our age." It is important that you ask yourself certain questions before defining your desired outcomes. How much time do I have? What area of the organization will I affect? Who will be involved in the solution implementation? To what extent do I want to solve the problem? What, if any, constraints do I have concerning cost? By asking yourself these questions or posing them to the group you will be less likely to list desired outcomes that are unreasonable.

The desired outcomes that are to be used in the solution identification may be generated by an individual outside the group or perhaps by the leader of the group. If you are working as a group, then the group should develop a consensus on the desired outcomes. Look at the criteria and constraints that you had set for yourself during the problem identification step, and the primary causes identified through the data collection process. An example of some possible desired outcomes that may be generated when identifying ways to “Improve cooperation and coordination between trades and supervisors" might be:

- Improved planning and scheduling
- Closer adherence to schedules
- Improved communication

Solution Identification

Through the previous sections you have identified a problem or problem area. You have brainstormed the problem to identify the

causes contributing to the problem. By collecting data using process charts, work sampling, or one of the other methods described, you have been able to validate and quantify the perceived causes of the problem using the compiled graphical and/or tabular data representation. From this information and other constraints such as time, cost, manpower, etc., you have developed your desired outcomes. The difficult part is now in developing the solution to the problem identified that will meet your desired outcomes by removing in part or completely the primary causes to the problem.

Generating Ideas

Before starting to develop a solution to your problem a distinction needs to be made between ideas and solutions. This distinction will help in developing a high-quality solution that will be less likely to meet with resistance during implementation.

An idea should be thought of as an image or conception of how a problem might be solved. A solution is more refined than an idea and specifies methods or processes of how a problem can be solved.

Remember from Section II the importance of deferring judgement when generating ideas in groups. The ideas generated can be judged later. If the members try to list solutions from the start instead of generating ideas they are likely to end up with a lower quality solution.

When generating ideas for solutions refer to the questions that were raised in Section II when the problem was identified. Look at the constraints and the desired outcomes and let these guide you through the idea generation and evaluation.

The two types of idea-generating techniques discussed in this workshop have been brainstorming and the Nominal Group Technique (NGT). Brainstorming uses Oral idea generation, while the NGT uses written silent idea generation. Both methods have their advantages and disadvantages.

Your selection of the technique to be used will be based on the needs of your particular group. For instance if it's important that the group be able to interact and a less structured approach is desirable, then brainstorming would be more appropriate. On the other hand if it’s necessary to avoid interpersonal conflict, and a more structured approach is necessary, then the NGT would be more appropriate.

Classical brainstorming was discussed in detail previously in section five. Briefly it involves four basic guidelines; (1) No criticism of ideas is allowed while generating ideas. (2) Freewheeling is desired. (3) Quantity is wanted - The more ideas generated the better the quality of the final solution. After ideas have been generated it is desirable to combine, clarify, and improve on these ideas. A typical brainstorming session was discussed in Section II.

The Nominal Group Technique (NGT) was also discussed in detail in Section II. Briefly this technique involves (1) silent generation of ideas in writing. (2) round-robin recording of the ideas that were generated. (3) a discussion for clarification of the ideas. (4) a preliminary vote and ranking of the ideas. (5) a discussion of the results of the vote and, (6) a possible final vote.

Evaluating Ideas

Once a list of ideas has been generated, the ideas must be assessed and narrowed down so that one or more potential solutions can be implemented.

Before an idea can be selected, it must be evaluated. It is necessary to use your criteria from Section II as well as any other criteria which you have developed as the basis for your selection. Once you have applied your criteria, the selection process should come easily.

Often ideas are selected with little consideration to the basis for the choice. When ideas are selected without consideration of meaningful criteria, the odds are high that a low quality solution will be chosen. To increase the chances of choosing a high quality solution, everyone should clearly understand the importance of the criteria to be used in the decision-making process.

In group and individual decision-making processes, the criteria used to guide the idea selection will be explicit, implicit or a combination of both. Implicit criteria are used when an individual applies his or her own criteria without sharing that criteria with other members of a group. Explicit criteria are used when the group has formerly agreed on specific criteria to be used in selecting an idea. A combination of both explicit and implicit criteria is utilized when the group agrees upon certain criteria but the individual consciously or unconsciously uses his or her own criteria as well.

It is important in group problem solving that explicit criteria be used whenever possible in selecting ideas. It will be much easier to develop a consensus on a selection when explicit criteria are used to make a selection.

If the group has generated a large number of ideas, it will be necessary to reduce this number to a workable size. This process was covered in Section II in the discussion of the NGT and Brainstorming. Some additional methods will be presented here.

One possible approach would be to consider a certain criterion, apply it to the ideas, and eliminate all ideas that don't meet this criterion. An example might be to eliminate all ideas that would cost more than a certain sum of money to implement. Choose this criteria carefully because good ideas may be eliminated.

Regardless of the approach used to eliminate ideas, the group must come up with a final list of ideas for evaluation and selection. The group should use as many explicit criteria as necessary. Choosing the specific criteria to be used here can be as easy or complex as you want, but be sure that they take into considerations the constraints developed in Section II.

There are three procedures that may be used for applying the criteria: voting, evaluation, or some combination of the two. Again, time shouldbe considered when choosing which method to use.

Table 1

	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Total
Idea 1	X		X	X	3
Idea 2	X				1
Idea 3		X	X		2
Idea 4	X	X		X	3

The Nominal Group Technique (NGT) maybe used if time is not an important factor. Also when using the NGT, the group should be sure that they have developed explicit criteria to ensure consensus in the voting procedure.

The group may also brainstorm a list of pros and cons using the explicit criteria developed (Table 1). The group or individuals

list the criteria across the top of a sheet of paper or a flip chart. To the left of the criteria, the ideas are listed in a single column down the side of the paper. For each idea, a check is made under each criterion that is an advantage. Now select the idea or ideas with the most check marks.

A slight modification of this method would be to assign a value to each criterion (Table 2). For example, using a 5 point scale (1 being low importance and 5 being of high importance), evaluate the importance of each criterion. You would then give the idea the criteria weight and sum these weights.

Table 2

	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Total
	2141511				
Idea 1	2		5	1	8
Idea 2	2				2
Idea 3		4	5		9
Idea 4	2	4		1	7

This can be modified further by assigning a weight to each idea as to how it meets the particular criteria (Table 3). If it requires little time and one of the criteria is time, then you may **want to give this a rating of** five. The two weights would then be multiplied and the total criteria summed.

Table 3

	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Total
	2	4	5	1	
Idea 1	3 / 6		2 / 10	5 / 5	21
Idea 2	5 / 10				10
Idea 3		2 / 8	5 / 25		33
Idea 4	4 / 8	5 / 20		5 / 5	33

At this time, you can select an idea based on the results of the procedure applied. you should now reassess the idea quality using a subjective rating. You may ask the group members to judge an idea based on the probability of it solving the problem

being addressed. Review your desired outcomes and evaluate how the solution selected meets each of these.

Implementation Plan

Now that you have developed and selected a solution you must consider the implementation of the particular solution.

Implementation is a critical step in the problem solving process. A high quality idea with a high probability of solving the problem will have little chance of succeeding if the solution is not implemented properly. An inappropriate implementation may magnify the problem or it may create an entirely new problem.

There may be resistance in taking the time to plan for, implementation. Many times the group is tired of the process and has already exerted so much effort in the previous steps that they just want to get it over with. It's important that the group continue the process and not look for a way out or a short cut to solving the problem. Problem solving is a cumulative effort with each step of the process building on the previous steps. Therefore, if the group were to stop at any step, all of the previous efforts would be in vain.

In order to sell your idea, you should develop an implementation strategy. How a solution is to be implemented can be just as important to the audience when making your presentation as the solution itself. You or the group must have a plan to guide the implementation.

The group leader must make the decision whether the group members should be involved in the implementation. Again, time is an important consideration but one must also consider the group and their position personally and professionally. Implementation of

the solution may require you to consider implementing the idea yourself.

The group should develop a list of potential problems or **Ilroadblockst!** that may prevent the idea from being implemented. Discuss the possible causes of each potential problem and ways to prevent each problem. This will help prepare you for questions that may be asked during your presentation to sell your proposal. In addition, when making your plan be sure to thoroughly assess your resources (i.e. time, people, capital).

A good check in developing your implementation plan is to ask, yourself Who?, What?, Where?, When?, and Why? regarding each implementation task being developed. For example: Who will implement the idea? Who will be affected by the implementation? Who should be notified of the implementation? What needs to be done? What will it cost to implement the solution? What are the benefits of implementing the solution? Where will the idea be implemented? When will implementation begin? When will the implementation end? For each of the five "W's" be sure to ask. "why?". When making your implementation plan be sure to include deadlines for when phases of the solution or the completed solution will be implemented. Include evaluation dates for the solution and the implementation will be checked for completion and the degree of success or failure.

V. SELLING THE CONCEPT

Overcoming Resistance

Resistance to change is a major impediment to methods improvement activities in most organizations and shipyards are no exception. As irrational as such resistance may seem at times, it does serve the purpose of testing new ideas so that they will not be accepted and implemented prematurely. Once you understand the individual and organizational obstacles that inhibit change, you will be able to develop your creativity more fully and "sell" your ideas more successfully.

Even after you've worked out a tough problem, you may find that no one is interested. Sometimes this is due to lack of confidence in merits of the idea, but most often it is due to your neglecting to get others involved in your solution.

Methods improvement implementation requires cooperative effort. But Many people get SO ego-involved with their ideas that suggestions for modification are automatically opposed as unnecessary tampering. As a result, they fail to elicit the participation and cooperation of others during the development and implementation stages.

Suggestions for improvement should be heartily welcomed. When others take an interest in your idea, they become personally involved; your idea becomes "our idea.11 If you are generous in sharing the idea with others, and in incorporating beneficial suggestions, everyone will be a winner and you will be remembered as the one who came up with the original concept in the first place. On the other hand, if you cling to the purity of your idea too strongly, others will not come to your aid when you run intc obstacles. Insistence on receiving all the credit for an idea is

not only unrealistic in most organizations; it is the quickest route to resentment and lack of cooperation.

Threat to Authority or Position

Some people react negatively to new ideas because the ideas are not their own. Managers and supervisors are especially prone to play down the value of new ideas because they feel that their power and status are threatened if their subordinates or associates suggest them. They believe that if changes are necessary, they should be the ones to think of them.

Change is also frequently fought because it makes someonets job insecure or tumbles an expert from his pinnacle of recognition. For example, a technical innovation may introduce a new approach to a particular job. A person who for years has followed a proven practice with great skill and confidence may suddenly find himself to be a novice who is feeling his way down the painful path of learning a new skill. He may feel that the change threatens his earnings or his chances for advancement or recognition.

Perhaps the most prevalent reason for new ideas being viewed as a threat to existing authority or position is when the ideas that originate in one department directly affect people in another department. In the typical organization, each person's responsibility is carefully defined and looked on as his own special preserve. When somebody comes up with an idea that concerns another person’s area of responsibility or expertise, the usual reaction is defensiveness or hostility. The affected person feels that someone is trying to trespass into his area of authority and responsibility.

This artificial but very serious barrier to change not only kills a lot of valuable ideas; it also prevents the free flow of

information and communication that should exist between departments. At the appropriate time during the solution development phase, you should involve those affected in other departments and their concerns should be addressed. If you wait until the implementation phase to consult others affected by your solution, you may meet resistance you cannot overcome.

Gaining Management and Labor Acceptance

In order to gain acceptance of your ideas from your audience, regardless of whether it is labor or management it is essential to address their concerns. The following questions should be considered from the perspective of your audience when preparing your presentation:

1. Why should I listen?
2. What is it?
3. Who says so?
4. What's in it for me?
5. Why should I do it now?

Answering those five questions within your presentation should enable you to sell your ideas effectively.

Presenting to Management and Labor

A lot of people can’t sell their ideas. They may simply be afraid of rejection or, more likely, be reluctant to undertake the work. involved in preparing an effective presentation.

Presenting ideas to management for approval or to labor for acceptance is difficult. When preparing the presentation, their may be some disagreements among the group as to what shall be included. Although these disagreements will need to be resolved,

they are an indication that the group is concerned about the validity of what is being said. More importantly, this indicates that the group has developed a sense of ownership of the ideas and a desire to see improvements implemented. The group must feel comfortable with the final presentation and have confidence in everything they are saying. Therefore, it is necessary to leave enough time to prepare and rehearse the presentation before making the "big" presentation.

Often the person you're submitting your idea to won't even realize that there is a need for change. Your presentation should follow the logical steps of the methods improvement process and your reasoning from the beginning should be clear.

Presenting a new idea is, in many ways, one of the most crucial aspects of the methods improvement process. Here are some ways tc improve your chance of success:

1. <u>Presenting to a group.</u> Try to sell your idea to one or more of the members before the meeting. They'll appreciate your advance confidence and, possibly, rally to your side if the going gets rough during the presentation.

2. <u>***Give*** background information.</u> Before actually presenting the idea, give a short history of the problem what led you to investigate the area, and how you selected that particular problem. Include the causes of the problem and the desired outcomes of the solution in the presentation.

3. <u>Show them voulve thouaht it out.</u> Demonstrate by your conversation that this idea isn't the first one you've dreamed up. You've thought the problem out and made various approaches and refinements until you're satisfied that you have something worthwhile. The person who goes off half-

cocked all the time may be fine to stimulate others around him in an idea session, but when you're ready to "sell" an idea, you must be prepared to prove that you’ve thought it through.

4. Go s1ow1v. The presentation of the new material should be delivered no faster than it can be understood and absorbed. Clear language is absolutely necessary. Take special care to eliminate trade jargon unless your audience is at home with such language.

5. Don't knock the status uuo. Your audience may have been intimately involved in getting things running the way they dc now, so don't be hypercritical of "things-as-they-are.tt Instead, talk about the better times ahead -- if your idea is accepted.

6. Sum up. At the end of your presentation, sum Up the outstanding points, the anticipated advantages of the idea, the need that exists or can be created for the idea and why you think the idea should be adopted.

7. Put it in writina. Not everyone is constitutionally capable of following an oral presentation, so stack the odds in your favor by leaving copies of a clear, well written report with your listeners. This will give them a chance to study it later.

8. Anticipate Questions. Before the presentation, consider the probable reaction of your audience to your ideas. Anticipate questions they may ask and prepare answers. Presentations can be tense situations and it is much better to be prepared for tough questions than be caught off guard.

When presenting to management, here are some additional points to consider:

9. <u>State Management Support Remired.</u> It is important that you explicitly inform management of any support that is required from them for successful implementation. These points should be presented in writing and should be discussed with management. If management support is necessary, it is important to know for certain that it will be present before implementation is begun.

10. <u>Emphasize the money angle,</u> where appropriate. When selling an idea to top management, remember that a strong dollars and cents case must be made. The possible savings potential or profit potential should be demonstrated and the presentation should include plenty of business benefits, not just an explanation of how it works. Intangible benefits such as improved morale or interest in job should be included as well.

<u>Acceptance by All</u>

Although there may be a formal presentation in which you will hopefully receive approval for your ideas, that is not the only time you will have to sell your ideas. For implementation to be completely successful, you need to sell your ideas to everyone at all levels who may be affected by the changes made. An example is the need to sell middle management on improvements devised by front line supervisors. This is especially important if upper management endorses the implementation of the proposed solution. Middle management should be given a complete presentation regarding the solution development if they are expected to support implemental ion.

This example is not meant to criticize having front line supervisors such as production foremen developing and implementing solutions to problems. Instead, it is intended to emphasize the importance of consulting everyone that will be involved in making the implemented solution work. It is not recommended that you allow others, including upper management, to sell your ideas for you. Chances are they will not be familiar enough with the details to make an effective and convincing presentation.

Implementation/Follow-UP

After you have sold your idea and have started your implementation, it will be important to follow-up the implementation to see that the ideas are implemented as designed. It will be important to choose an individual or members in the group to follow-up with the implementation. If the solution has been fully developed and the implementation plan thought through, it will be important to see that the implementation goes as planned and that the chosen solution is implemented as intended. If a solution is implemented only in part, then some of the effort that preceded will have been in vain.

It's important that this process continues as long as it is necessary so that the individual or group can be satisfied that the idea will not be dropped. Often it is difficult for people to accept change. What could happen is that once the idea is implemented, it might be dropped by those involved that were opposed to the change. If they are questioned the reply would be, “Well, we tried but it just didn’t work.”

Evaluation

It is also important after a problem solving process has been implemented that the group or individual do some type of evaluation

of not only the success of the improvements but of the problem solving process itself. Have members evaluate the process and comment on the approach, the group leader, and the improvements. Evaluate the implementation. How well was the plan thought through? How well did the solution meet the desired outcomes? Were all the necessary people involved in the implementation? Surveys which were discussed in Section VI may be helpful here. This is an important step to ensure follow-on methods improvement programs will be accepted. If you cannot show the success of your program it is unlikely that future support will be easily found. By showing not only the success is but that you were able to locate the failures or inadequacies of the process, you have shown that improvements are being made in your methods as well as the company's, and the process will be more likely to gain support.

VI. SUMMARY

This workshop has provided you with guidelines for developing and implementing methods improvements. The steps of the process are:

- Selecting the appropriate participants: those who will be affected by changes in the area to be studied and those who have knowledge of what to change and the willingness to help implement change.
- Identifying problems in a particular area and then selecting a specific problem to be solved given limited human and physical resources.
- Identifying the perceived causes of the particular problem selected.
- Verifying and quantifying the primary causes of the problem through the use of various data collection techniques.
- Identifying possible solutions and selecting a particular solution based upon specific criteria.
- Presenting the solution developed to management for approval and labor for acceptance.
- Implementing solutions developed to improve the quality of work life for all affected.
- Evaluating the impact of the solution implemented and refining the solution to maximize the possible benefits.

Although a specific procedure for methods improvement has been presented, the process is flexible. For example, the data collection techniques can be applied as part of the problem identification step. Also, a highly participative approach to methods improvements has been presented. Although full participation of those affected will enhance acceptance of the solutions proposed, it is quite time consuming and you may not always have the time for participative decision making. Depending

on your situation, certain steps can be added, rearranged, or deleted. Above all, the steps must be logical and correctly carried out so that the results that can be presented with confidence.

APPENDIX A: REPRESENTING THE DATA COLLECTED

Early on we talked about the "questioning attitude.lt We do not question because we are congenial skeptics; we question because it' a good mental attitude to have when looking to solve problems. A questioning attitude, used in conjunction with standard data collection techniques, will facilitate methods improvement.

Methods improvement requires measurement and definitive information. Communicating the situation to others requires an understanding of the problem and a clear and understandable presentation. Once a problem is identified, you need to validate the existence and extent of the problem. This usually requires the taking and presentation of data. Before any numerical data can be interpreted, you need to compile it into a form that is easily understood. Some effective ways to present the data include:

1. Flow Charts
2. Charts, diagrams and curves
3. Scatter diagrams
4. Histograms

Before we start on data presentation, a few observations:

- Remember that this is not a mathematics course. Data presentation is just a way of graphic communication. Data collection, simple arithmetic operations such as grouping or calculations, and graphic presentation of the data definitely helps the understanding of the problem by all.

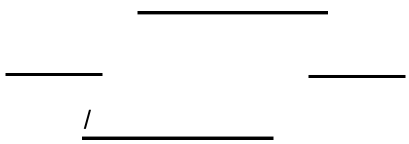
o Most data follow Pareto's Law, named after an Italian mathematician. He observed:

1. Things often break down into a trivial many and a critical few.

2. In most business activities, a small fraction (approximately 20 percent) of the total item count produces the major portion (around 80) of the work, cost, profit, or other measures of importance.

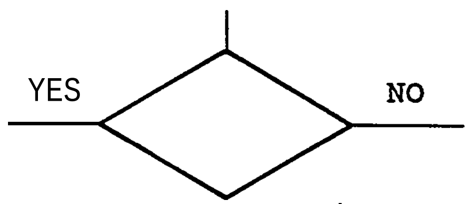
Flow Charting

You have received examples of some of the industrial engineering type flow charts. Don't get too fancy. In an initial phase, use some of the symbols of logic or "computer type" flow charts. Some of these are:

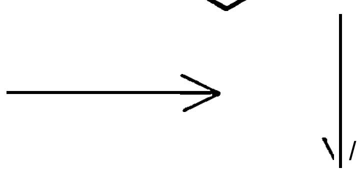


Input or Output Devise

Processing



Decision



Direction of flow
Usually left to right,
top to bottom

Charts, Diagrams, and Curves

Charts present data graphically. Usually, people can comprehend better with an image than with just the data; and, a combination of the two is stronger than either by itself. Many times, the significance of the data collected will not be clear until the data is displayed graphically.

Where we measure is usually taken from the problem itself. Very often the calendar of working days is taken as the independent variable or some other known or controlled variable. The quantity

that varies as a function of time or other controlled variable can be plotted in comparison. Dollars spent, manhours, percentages, o dimensions, and outgoing quality are often dependent variables.

One of the first ways to present data is with a chart. With only five or ten readings, this method is sufficient. Chronology is plotted in one vertical column from top to bottom and the other variables are entered opposite the values in parallel vertical columns .

Here are some ways to present data showing a comparison of order size (independent variable) and production cost (in this case operation hours) .

The raw data as obtained from accounting: order size - operator hours.

30 - 120	53 - 176
48 - 161	25 - 130
35 - 140	33 - 130
45 - 165	39 - 150
40 - 160	45 - 150

The raw data shows us information but itcs hard to make much sense of it.

The first step is to arrange the data into an ordered array tabulation by putting the independent variable in numerical order. This would give:

ORDER QUANTITY	OPERATOR HOURS
25	130
30	120
33	130
35	140
39	150
40	160
45	165
45	150
48	161
53	176

Many other charts and diagrams are available to present data. Just remember the concept of independent or controlled variables and the associated dependent data (bivariate data) .

Of special interest is the scatter diagram (see Figure 1, page 90). It is a graph showing the independent variable plotted on the Y-axis. The scatter diagram shows more information than the charts previously shown. First, it shows whether a simple relationship exists. This is much easier to determine than looking at charts. Second, it shows how linear or how close the relationship is to a straight line, or “fair" curve.

Taking the diagram (Figure 2, page 91) and using some practical “regression analysis11 will show that the set-up cost per order is about forty man-hours and the cost per piece is around 2.7 hours in quantities greater than 20 (from the slope of the line) . Because the scatter doesn't begin to level out, the operator time does not get any less in quantities up to 50. Whether these conclusions are valid, though, will require more knowledge.

Figure 1

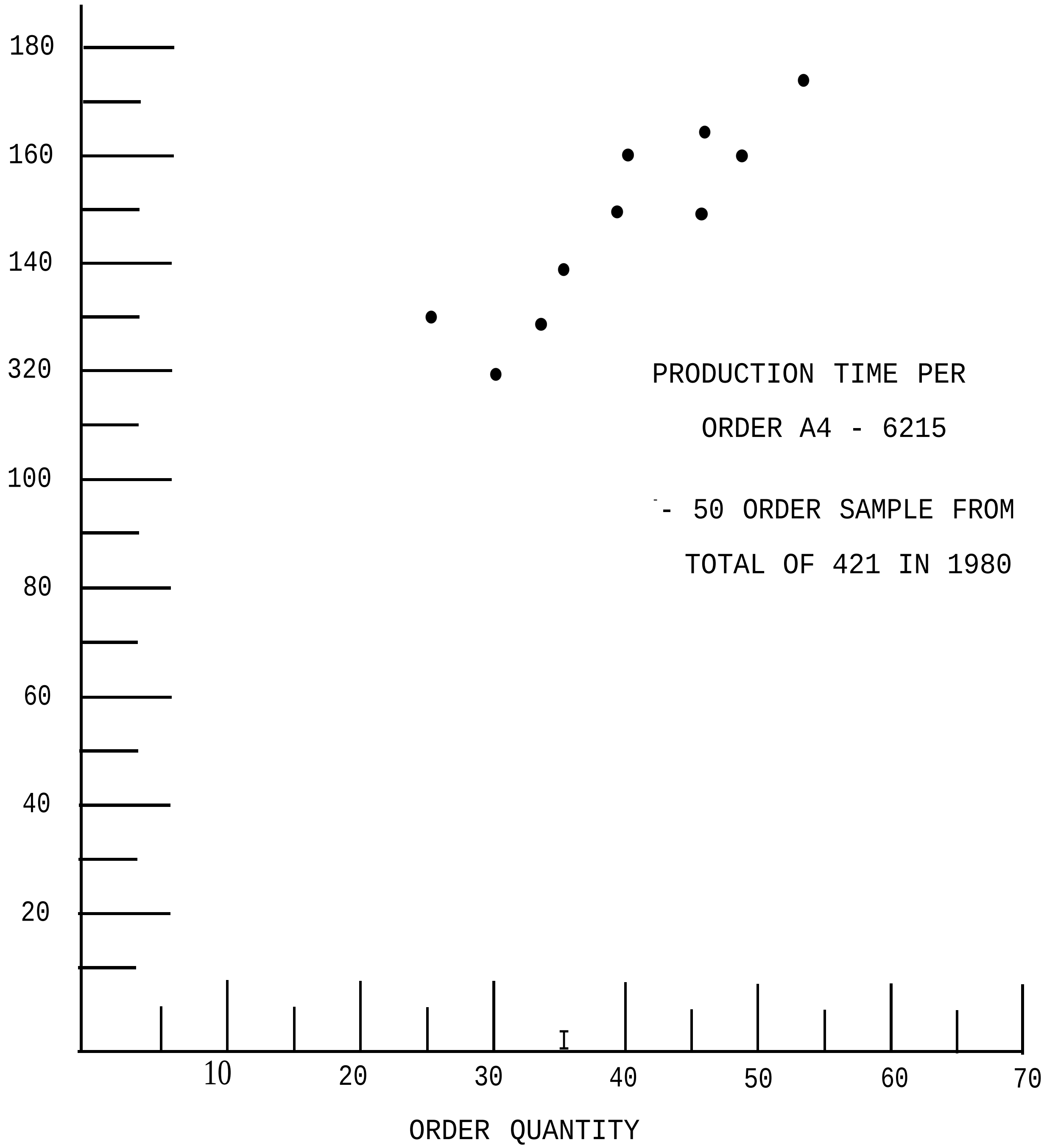
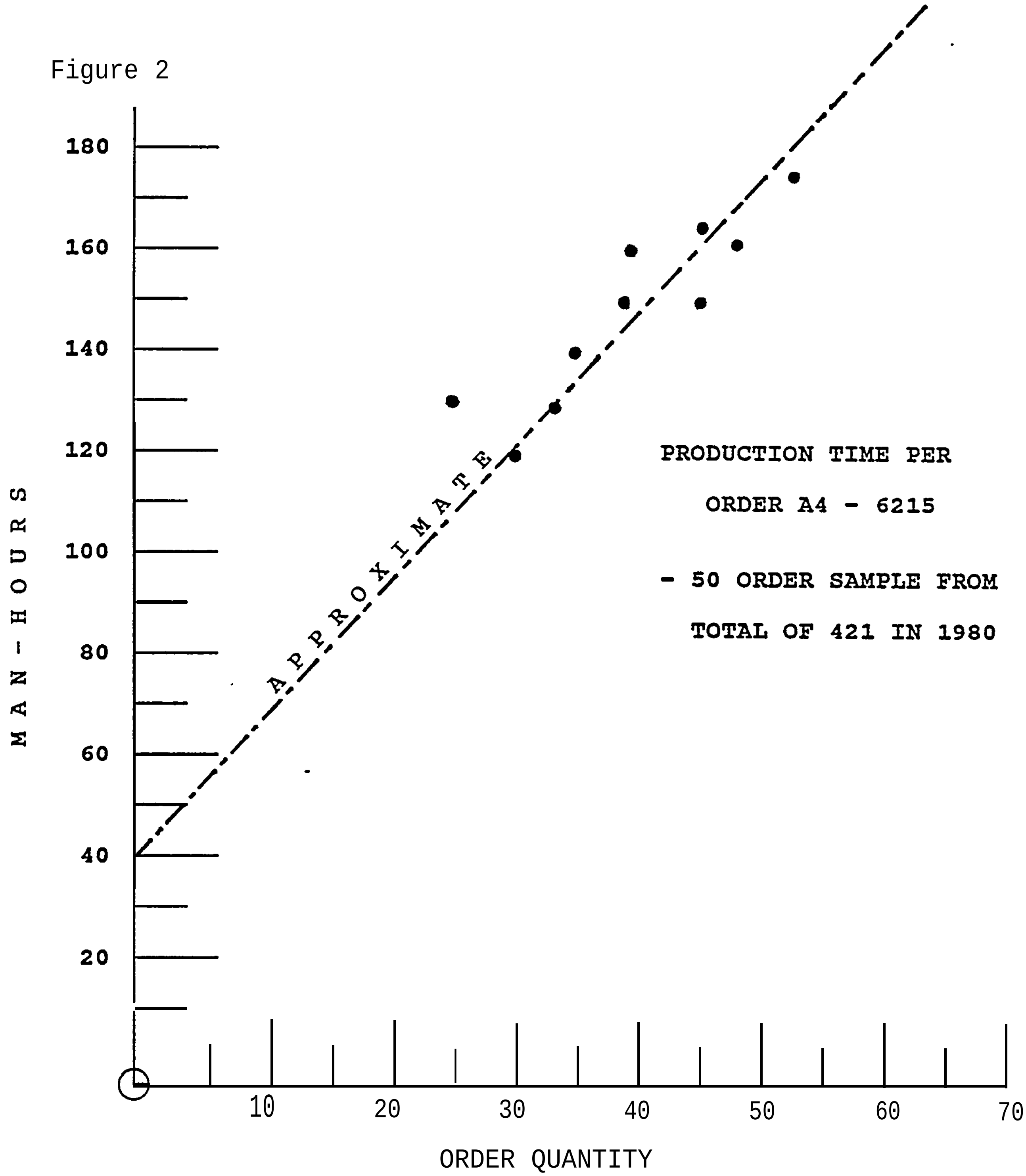

180
160
140
320
100
80
60
40
20
PRODUCTION TIME PER
ORDER A4 - 6215
- 50 ORDER SAMPLE FROM
TOTAL OF 421 IN 1980
10
20
30
40
50
60
70
ORDER QUANTITY

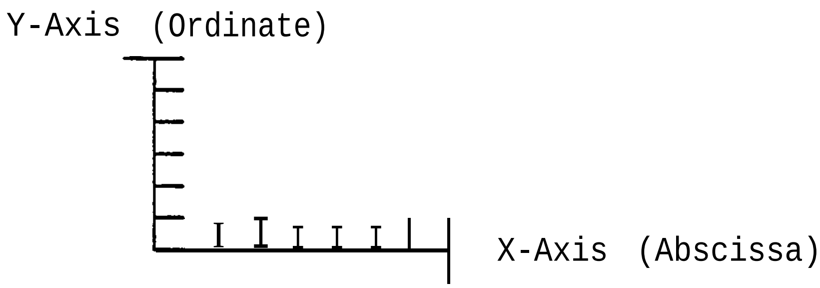
Figure 2



180
160
140
120
100
80
60
40
20
MAN - HOURS
APPROXIMATE
PRODUCTION TIME PER
ORDER A4 - 6215
- 50 ORDER SAMPLE FROM
TOTAL OF 421 IN 1980
10
20
30
40
50
60
70
ORDER QUANTITY

Conventions in X-Y plotting are: the X-axis (horizontal) is the independent variable, or abscissa. If you can adjust it, or select it, the variable is independent. The dependent variable, or ordinate, is plotted on the Y-axis or vertical axis. The dependent variable is a function of the independent variable.

Families of tunes result when a third, adjustable variable is held constant while the other two are varied and plotted.



Within these definitions you would normally plot time, hours, days, the calendar, orders, etc. on the X-axis. The Y-axis often includes hours worked per day, standard hours produced, percentage of total, output, dollars spent, variable time, utilization, yield, rejects, etc.

<u>Histocmam</u>

A lot of single-value numbers (univariated data), perhaps 30 or more, present a different problem. Several established ways are ordered array, averaged, or plotted as a frequency histogram.

The histogram is a graphic devise for univariated data and is quite useful because it conveys the impression of the shape and pattern of the distribution at a glance. It is handy in showing information where you are interested in the median or central tendency, or a production distribution with high and low rejection points.

Typically, histograms are plotted using samples of 30 to 100 or more. Usually the quantity is plotted along the vertical or Y-axis, and cells or classes are set up along the horizontal or X-axis. The number of cells is important and should be selected with an idea of clearly presenting the information wanted. If you have upper and lower control values, you may want to put these at an edge of a cell so that the histogram clearly shows whether the parts are acceptable or rejected.

Here is a chart showing typical numbers of cells for various numbers of observations. Adjust as indicated.

NO. READINGS	NO. OF CELLS
30	6
50	7
100	8
200	9
400	10
1000	11

For setting Up cells, the “break points,lt or intervals, may well follow your own convenience. Groups of 5 or 10 may be handy, or use other convenient intervals. On the other hand, if lots of values fall on whole numbers, you may want to set your cells 4.6 to 5.5, 5.6 to 6.5, 6.6 to 7.5, etc., so that the value of 5.0, 6.0, 7.0 falls clearly within the cell and not on the transition value.

When a histogram or any chart or diagram represents a sample of a larger population, remember the quantity must follow the statistical sample number for the data to be valid. See Figure 3 for an example of histogram plotting.

Another way to show univariate data is to plot relative rather than absolute frequencies. The example histogram uses absolute

frequencies of the quantity, the actual count. These could have been easily converted to relative frequencies by expressing them as a percent of the total observation. This information would show more than an ordered array chart and it can be plotted using the percentages instead of the absolute frequencies.

Relative frequency tables and graphs are particularly useful when <u>two</u> frequency distributions involving different numbers of obsezwations are to be compared, such as a before and after comparison.

There are several other ways to present these kinds of data: cumulative frequency distribution, cumulative percentage frequencies, etc.

<u>Histocfram Example</u>

Production order man-hours per job, 50 samples.

55	40	16	18	31
93	84	15	25	80
82	88	37	32	89
53	72	18	40	12
68	32	29	42	32
50	36	21	20	17
81	10	30	25	14
79	09	35	26	21
22	40	35	19	43
21	12	25	27	25

Not much can be deduced from these raw figures although we could easily calculate the arithmetic mean:

$$X = \frac{\text{Iotal}}{N} = \frac{2040}{50} = 40.92$$

Setting up a histogram with 7 cells would have inconvenient values. Try 10.

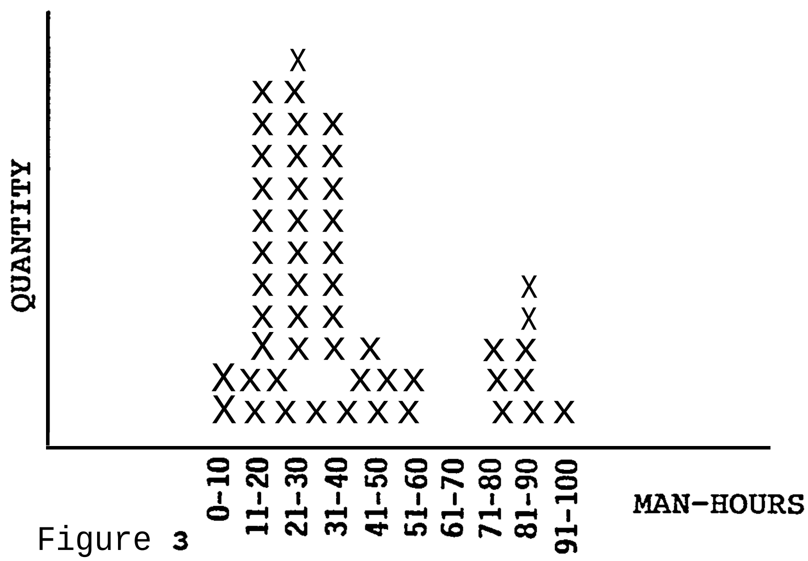


Figure 3

Other Wavs

We normally think of data presentation as an exercise involving graphs, charts, and figures symbolically representing a practical solution.

Other ways can involve photographs of the actual situation, photographs of models, sketches of the situation before and after, and video and film motion pictures.

Take data and present them carefully. Good data helps us understand the problem and sometimes has an uncanny way of leading us to a solution.

APPENDIX B: STATISTICAL TERMS

The quality of data has an important influence on outcome. Figures, charts, and diagrams give the illusion of being correct and valid. Technology-minded people must concern themselves with making the illusion a reality.

To review:

Data — One or more measurements or observations. Data is plural; a single measured or observed value is a datum.

Accuracy — This expression is a measure of the difference between the data and the true value of whatever the data represents. Usually expressed as a percent.

Validity — A number or numbers are said to be valid if they measure what they claim to measure. Valid data is that appropriate for the use intended.

Precision — A measure of the repeatability of the data. It may be inaccurate, but similar observations produced similar results. Don't use precision when you mean accuracy.

Sample — A group of observations drawn from a universe or population. Done properly, a sample gives knowledge of the universe “from which it came”. The sample size must be large enough, given the required accuracy and confidence levels, and be taken in a random way.

Constant	A number that has only one value or does not change within a given context. Often takes symbol, a, b, or c.
Variable	A variable is a type of quantity that can have a different numerical value depending on another variable. In bivariate data there is the indendendent variable, usually given an X value, and the dependent variable, the values usually read or obtained, usually with a Y-axis value.
Average	The arithmetic mean derivedby taking them of the observations divided by the number of observations in a particular sample. Soxnetimes called X. Be careful using averages -- they might not be valid for the use involved.
Median	The middle observation in a set of data. If the data are arranged in the form of an ordered array (for example, in order of magnitude), the median is the half-way point: half of the readings are above and half of the readings are below the value. Sometimes called the 50th percentile or midpoint.
Ratio	A comparison of one attribute of data with another attribute of the total. The expression clearly requires what is being compared to what. Often used for a small quantity of data.
Percent	The term literally means ICnumber per hundredlt, from. the Latin work for one hundred. It is a fraction obtained by comparing the deviation with the standard and converting the **ration to llper one** hundred[ts]. Often used for **large quantities of data.**

Confidence **A measure of how much confidence can be placed in "the value** of a sample. Confidence limits are placed (for example 90%) so thatwe canbe (90%) sure that an interval, based on the sample, includes the universe values being sampled. Confidence means . that after a sample is made and calculated you can say, "I am certain that 9 out of 10 times (the 90% example) my calculated inference based on the sample is correct". Se the work sampling charts for use of the confidence levels.

Common sense would indicate that data taken from samples cannot have 100% confidence. But the larger the sample, the better the chance, and confidence approaches 100 percent. .

Random Numbers

When a sample is taken from a universe or population, it is necessaryto draw it with an eaual probabilitv **that the sample represents the true population. It is important that every element in the universe have an equal chance of entering the sample. To aid this selection, random numbers are usually used to generate the selection** criteria. Among others, random numbers can be obtained from tables or the telephone book.

METHODS IMPROVEMENT WORKSHOP
NOMINAL GROUP TECHNIQUE SESSION

WHAT ARE COMMONLY ENCOUNTERED BARRIERS TO CHANGE?

APPENDIX D: WORK SAMPLING EXERCISE

WORK SAMPLING EXERCISE

BACKGROUND

The decision to conduct a work sampling study had developed through a series of methods improvement meetings with the steel supervisors on the panel line.

1. Define the Problem: Through the use of Nominal Group Technique, the supervisors identified "low throughputll as a primary problem in their department.

2. Identify Perceived Causes: The cause and effect diagram allowed the supervisors to identify all potential causes of the low throughput. Everyone agreed that II no value activitiesll were high, and probably the largest contributor to **the "low** throughputil problem.

3. **Collect Data: .The " supervisors decided to** conduct a **worksampling study to verify** whether the %o value" activities were actually contributing to the low throughput.

This exercise will follow the procedure just outlined on how to conduct a work sampling study. When actually performing a work sampling, be sure to inform all individuals that will be affected by the study it;s all about. The eight steps are:

I. Define the Study
II. Preliminary Estimate
III. Plan
IV. Design an Observation Form
V. Carry out Plan
VI. Check Data for Control
VII. Check Final Results
VIII. Summarize Results

Panel Line Fitting Operation

The first step in fabricating- a panel assembly is the fitting operation .' For this exercise, the fitting & tacking of the plates into .paneis will occur on a conveyorized -panel.line. We will only be interested in the activities that occur at the fitting station.

I. Define the Study

For the purpose of this exercise we have surmised that the output of the . panel line is not up i;o expectations. Therefore, we would like to identify the percent of time already attributed to no value activities versus the value added and semi-value added activities. We will also want to identify major categories where it appears most time is spent.

Conduct a preliminary survey, or make a point to spend a day or a good portion of a day in the area to identify what you will be looking for in your future work sampling study. Try to establish activity categories and classify them as value or semi-value added vs. no value.

Observation	Value & Semi-Value Added	No Value

II. Preliminary Estimate

You could guess at the % occurrence of what you what to **measure,** however, in step I you have collected the data in order to establish a rough order of magnitude percentage of the time actually spent adding no value to the product.

Observations

Value & Semi-Value Added

No Value

$$\frac{\text{No Value}}{\textbf{Total}} = \text{\% Occurrence of No Value Added}$$

= - %

111. Plan

How many obsenations you make will depend on the percent of time the activity occurs and the degree of accuracy you wish to have.

In step two, we roughly determine that the no value added portion was _____% and the accuracy should be ±5%.

You can use the formula or the alignment chart.

$$N = \frac{4(1-P)}{d^2 p}$$

N = Number of Observations
P = _______ Percent of time activity occurs
D = _______ Percent accuracy

$$N = \frac{4(1- \quad)}{\quad 2}$$

$$N = 4$$

$$N =$$

$$N =$$

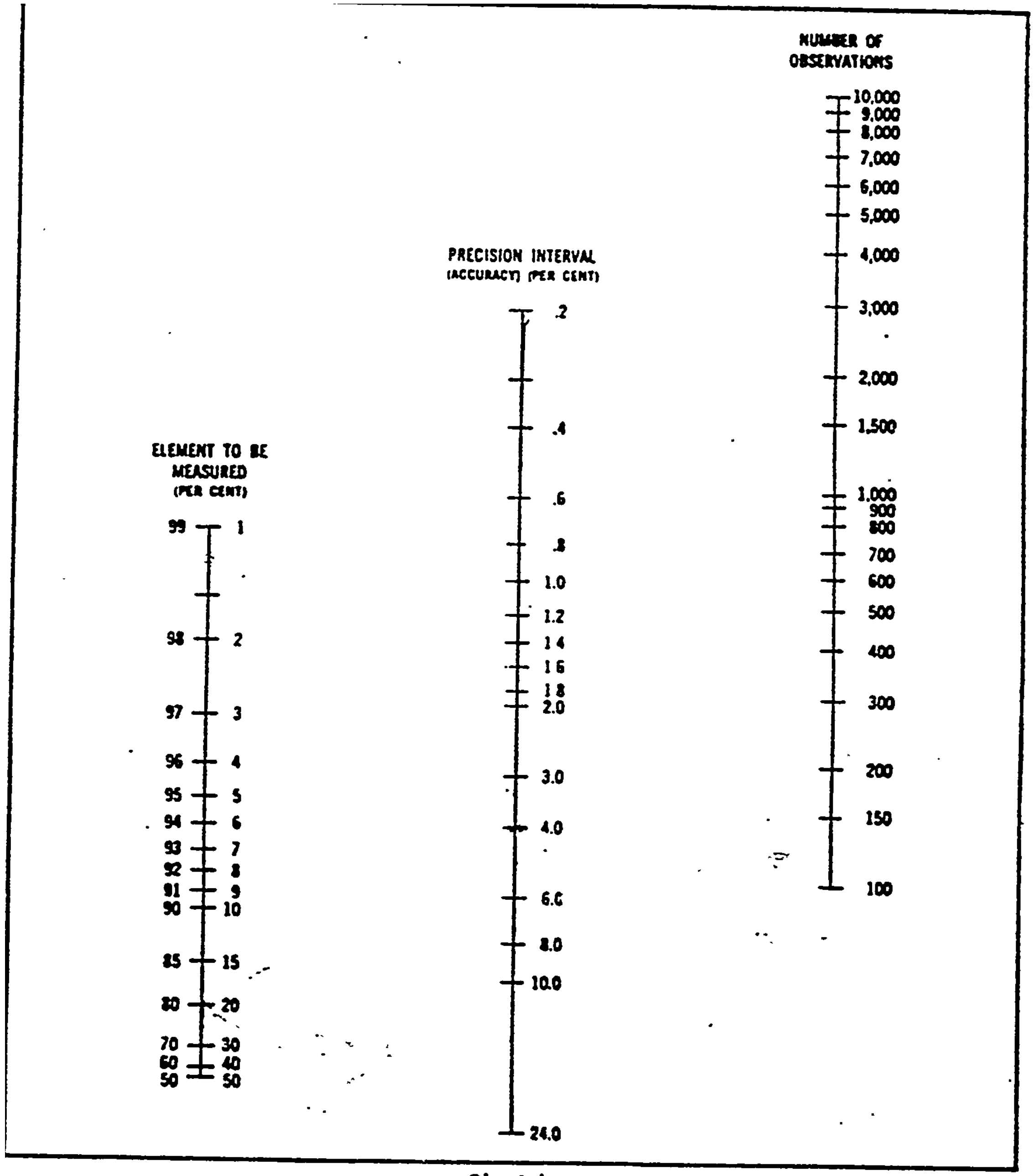


Chart I

NUMBER OF OBSERVATIONS

A. _____ X 5 = _____ Precision Interval

B. _____% of Occurrence of Category to be Measured

C. _____ Number of Readings to be Taken

It should be noted that the formula is much more precise in the number of observations required.

If this is a non critical operation and you do not need the precision of & 5%, you can save a considerable amount of time by going to ± 10% which is still very acceptable.

Example $$N = \frac{4\ (l-.36)}{.10^{2}{}''\ .36} = 711 \text{ Reading}$$

By loosening up your precision by 5%, you will have cut down the number of obsenations by 75%.

Chart 3

TABLE OF RANDOM SAMPLING TIMES

1	2	3	4	5	6	7
(19)0:05	0:20	0:10	0:15	(18)0:05	(23)0:10	0:15
0:20	(18)0:50	(16)0:35	0:25	0:25	0:25	(21)0:20
0:55	(24)1:20	0:55	(16)1:20	0:45	(21)0:30	(16)0:35
(22)1:10	(21)1:45	(24)1:00	1:40	1:05	0:40	(15)0:50
(20)1:20	1:55	1:10	1:55	(21)1:50	1:10	1:00
(24)1:35	2:00	1:45	2:00	(20)2:10	1:20	1:25
2:30	2:30	(19)2:00	2:30	2:20	1:30	(23)1:40
3:05	2:40	2:05	(15)2:50	2:30	2:25	(22)1:50
(16)3:10	3:10	(21)2:45	3:10	(19)2:35	2:35	1:55
(25)3:15	(23)3:30	2:50	(18)3:30	(17)2:50	2:40	2:45
3:25	(22)3:40	(22)3:00	3:45	(23)3:00	(24)2:55	(25)3:05
(21)3:45	3:50	3:20	3:50	(16)3:10	(19)3:05	3:50
4:00	4:05	3:30	4:30	3:40	3:15	(19)4:00
4:10	(16)4:15	(20)4:40	(20)4:40	(24)3:45	(17)3:25	4:25
(18)4:35	(17)4:20	4:45	5:10	(15)4:30	(15)3:30	(18)4:45
4:55	(19)4:25	4:55	5:20	5:00	3:40	(20)5:00
5:00	4:30	5:00	(17)5:30	5:45	(16)3:50	5:10
(15)5:05	(15)4:35	(18)5:55	(25)5:45	(22)5:50	4:00	(24)5:15
(17)5:35	5:20	(25)6:00	(19)5:50	5:55	4:15	6:20
5:55	5:35	6:05	(21)6:15	6:00	4:25	6:25
(23)6:20	6:15	(23)6:35	6:20	6:35	(18)4:35	6:50
6:45	(20)6:40	(15)6:40	(24)6:25	6:45	(22)5:40	6:55
6:50	(25)6:45	7:10	6:50	(25)7:00	(25)6:45	7:15
7:10	7:10	7:35	7:30	7:45	6:55	7:40
7:25	7:35	(17)7:50	7:55	7:55	(20)7:35	(17)7:45

8	9	10	11	12	13	14
(17)0:05	0:25	0:05	(25)0:05	(22)0:10	(25)0:10	0:10
(18)0:20	0:30	0:15	(18)0:15	0:20	0:15	(17)0:15
(15)1:05	0:40	0:40	0:20	0:30	1:10	0:20
1:25	(24)0:45	1:30	0:25	1:30	1:25	(22)0:25
1:30	1:00	1:45	0:55	(19)1:45	(21)1:30	(24)0:50
2:05	(18)1:10	(21)2:20	1:20	1:50	1:40	(18)1:25
2:25	(17)1:25	2:25	1:35	2:25	1:45	1:35
(24)2:40	1:40	(22)3:10	1:55	(25)2:35	(16)2:05	(23)2:10
(16)3:00	2:15	(20)3:40	(17)2:10	(17)3:05	2:40	(20)2:15
3:20	2:20	(15)3:50	2:30	3:10	(19)2:45	2:40
4:25	2:30	4:15	2:45	3:50	2:55	2:55
4:45	(15)2:40	(24)4:20	(21)2:50	3:55	(22)3:40	3:35
4:50	2:45	4:30	(22)2:55	4:05	3:45	(21)3:40
(25)4:55	(21)3:05	(25)4:40	(15)3:00	4:10	(18)3:50	4:35
5:05	(16)3:30	4:55	(16)3:30	4:50	(24)4:05	(16)4:45
5:15	3:35	5:00	3:35	(21)5:10	(20)4:25	(19)5:05
5:50	4:00	5:15	(23 3:45	(16)5:25	4:55	5:10
5:55	4:15	(19)5:20	4:05	(15)5:30	5:15	5:50
(22)6:00	(23)4:50	5:25	5:00	(24)6:00	5:45	6:05
(20)6:10	(20)5:45	(23)6:05	(19)5:40	6:05	(15)6:20	6:20
(19)6:20	(22)5:50	(17)6:45	(24)5:50	6:15	6:25	7:05
6:35	6:25	(18)7:15	6:25	6:30	(17)6:30	7:10
(23)7:10	(19)6:50	7:25	7:20	(18)6:50	6:35	7:20
7:15	(25)7:05	7:35	7:40	(23)6:55	(23)7:35	(25)7:50
(21)7:30	7:30	(16)7:55	(20)7:50	(20)7:25	7:50	(15)7:55

(Cont'd on next page)

Chart 3 (Cont'd)

15	16	17	18	19	20	21
0:50	0:15	0:05	1:00	0:05	(20)0:25	0:25
1:10	(23)0:35	(17)0:40	(16)1:10	0:55	0:55	(17)0:35
1:20	(20)0:45	(25)0:50	1:35	(16)1:00	1:30	1:00
(15)1:25	0:55	(23)1:10	(21)1:50	(24)1:25	2:00	1:05
1:30	1:00	1:40	1:55	1:40	2:50	1:10
(20)2:00	(19)1:05	1:50	2:10	1:45	(21)3:10	(20)1:50
2:20	1:25	1:55	2:20	(18)1:55	3:15	(18)2:40
(24)2:40	2:20	(16)2:00	(23)3:00	2:05	(24)3:25	(24)2:55
2:45	(21)2:25	(24)2:40	3:05	(17)2:40	(19)3:35	3:10
2:50	2:35	(21)2:45	3:15	(25)2:50	(22)3:40	(25)3:15
3:10	(17)2:40	(15)3:15	3:50	(21)3:15	3:45	3:45
(25)3:35	(25)3:05	4:20	4:30	3:55	4:00	3:55
(16)4:00	(15)3:10	4:30	(20)4:50	4:00	(17)4:10	4:15
(21)4:25	3:15	4:50	4:55	4:05	5:10	4:25
5:00	3:30	(19)5:00	(24)5:35	4:15	(25)5:40	4:45
5:10	(16)3:40	5:05	(15)5:40	(23)4:20	5:45	(23)5:00
5:20	4:05	5:20	5:45	4:45	5:55	5:25
(17)5:25	(18)4:10	6:05	5:50	5:15	6:20	(19)5:30
(23)5:35	4:35	(18)6:10	(18)6:15	(22)5:50	(16)6:30	6:10
(19)5:55	5:10	6:40	(19)6:20	6:10	6:40	6:45
6:00	5:20	6:50	(17)6:35	(20)6:35	(18)7:00	(15)7:10
6:15	5:50	(20)6:55	(25)6:45	(19)6:45	7:05	(16)7:30
(22)6:55	(22)6:00	7:00	7:10	6:55	7:15	(22)7:40
(18)7:25	6:15	(22)7:35	(22)7:20	(15)7:00	(23)7:35	7:45
7:50	(24)7:50	7:55	7:55	7:50	(15)7:55	(21)7:50

IV. Design an Observation Form

Identify the categories, then define each one so that there is no misunderstanding as to what they are.

Value Added

Tacking

Whenever **the fitter is striking an arc with his stinger in** a seam **between two plates.**

Semi-Value Added

Receiving Instructions

Any time that the fitter is talking to the supervisor of the area (supervisor can be identified as the person with the white hard hat and usually wears a tie).

Remove Slag

Whenever the fitter **is tapping the weld seam/edge of plate** with a slag hammer, **(slag hammer has point on one end and is** blunt on the other).

Material Handling

The fitter performs **several material handling operations. One is when the plate is loaded onto the panel line, and the other is when the panel is moved to the next station. Loading the plate onto the panel line will involve directing the crane operator to position the plate. When the panel is moved to the next station, the fitter stands at a control panel and operates the conveyor used to move the panel.**

Miscellaneous Work

Any and all other work related operations which have not been identified for the purpose of this study will be considered a working activity. Examples are walking across panel. relocating, and activating clamping devises, etc.

No Value Added

Personal

This category can be identified as personal in nature such as drinking coffee, reading the paper, having a snack, etc.

Not In Area

This category is used when the fitter is nowhere to be found. It should be noted that for this study, we have classified this category as No Value. If a great number of readings are recorded as not in area, it may by worth investigating whether some of these readings may be work related, thus value added or semi-value added activities:

Talk to Other Worker

When in a discussion with another worker is observed, it will be considered No Value. There is a possibility that it’s work related; you can usually tell.

The next step will be to design a form so that the observations can easily be recorded and tallied.

Operation ______________________________

D a t e: ______________________

B y ______________________

	Value Added	Semi-Value Added				No Value Added		
Obswmtlon Tim.	7ackIng	InstructIons	R.mevc Slsg	Material Hsndlhrg	Ml*e.	Personal	Not In Are.a	Talk With Other Workors
TOTALS								

V. Carry Out Plan

The study will be an 8 hour shift, starting at 12:00 noon and running to 8:00 pm with no breaks or lunches. The time will be called out in five minute intervals, when one of your times match with the one called out, observe the slide and record the activity in the appropriate category.

- **Use the form developed in Step IV.**
- **Each person follows his/her random time chart.**
- **Record obsenation time on form.**
- **Tally up observations for each category at the end of the study.**

VI. Check Data for Control

There are several methods for doing this - we will use a control limits alignment chart.

A) Average observation/Day = ______

B) Element Measured (No Value Added) ______

Using Chart 4, locate spot on right hand line and mark number of average obsenation/day _____ Then; mark spot on left hand line the percent of the activity that is being measures _______%. Connect the two marks with a straight line and read the center column for the study limits ______%.

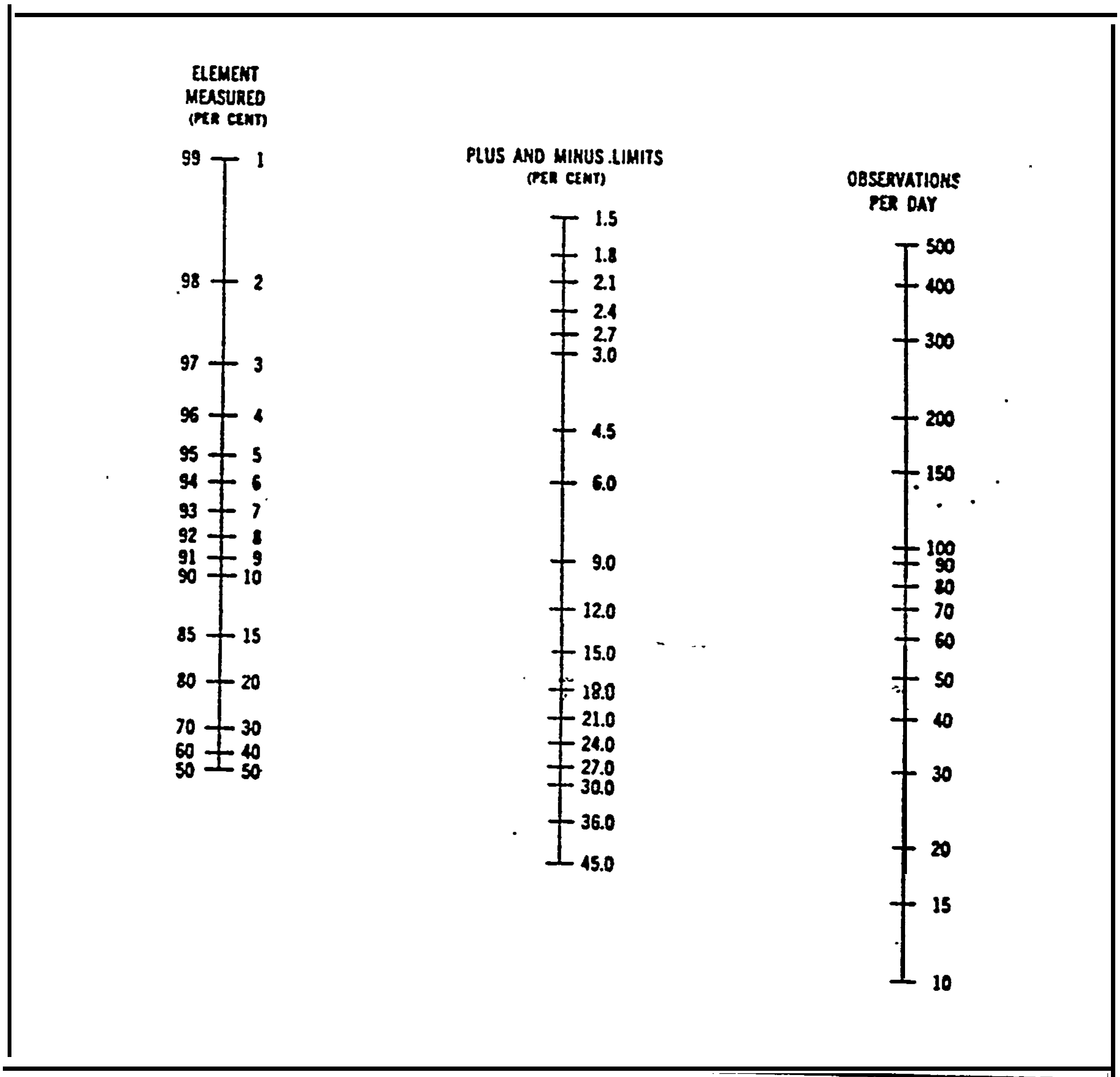


Chart 4 - CONTROL LIMITS for your Work
Sampling study results are found in this chart.

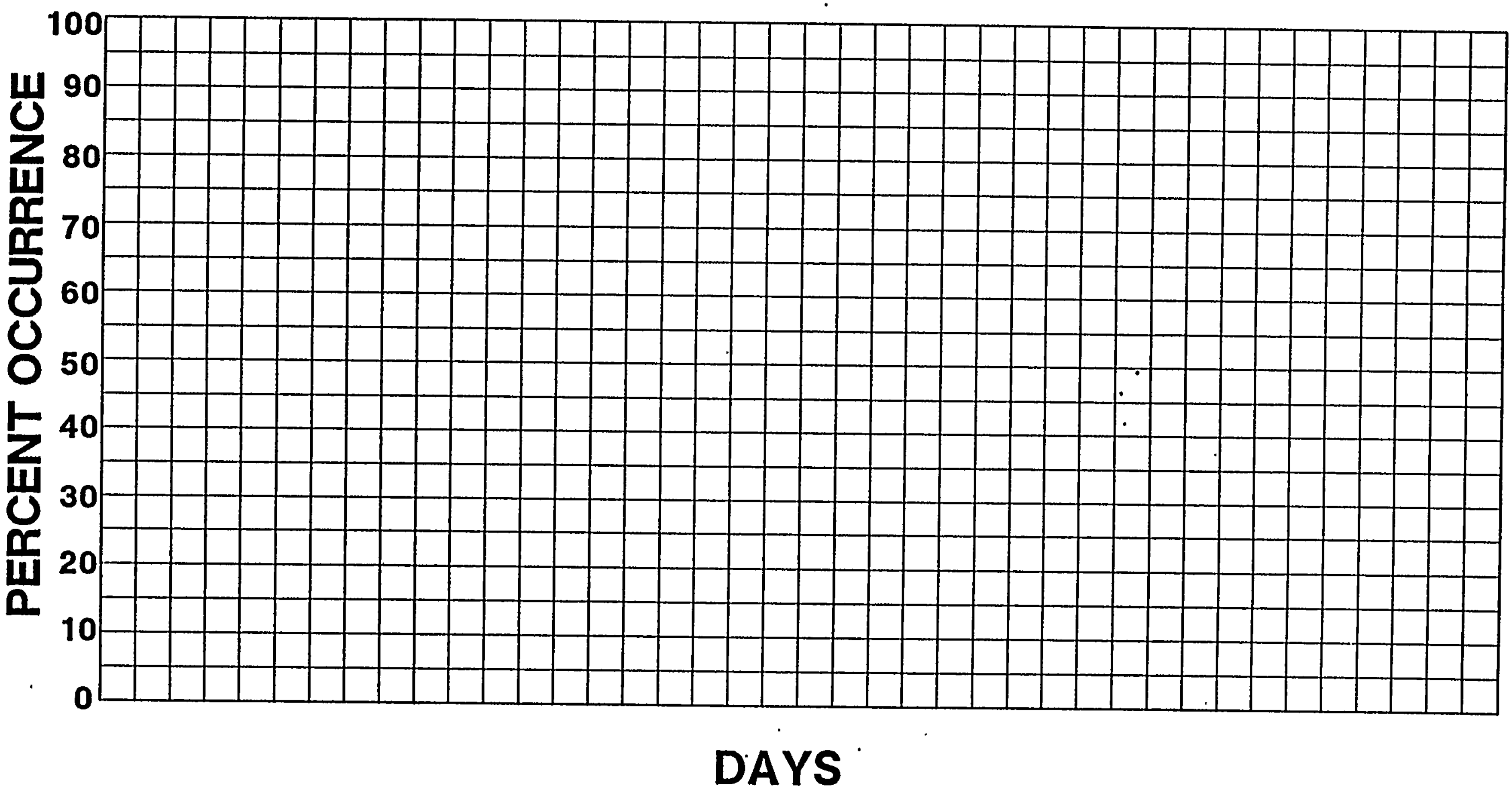
Add and subtract the limit % from the activity percent to give you the upper and lower control limits.

High Limit ______% + ______% =

Low Limit ______% - ______% =

Compare several of the individual readings to validate study.

PANEL LINE WORK SAMPLING STUDY
CONTROL LIMITS



VII. Check Final Results

Use alignment chart #1 in step 3 to see if you have sufficient number of readings to be statistically acceptable.

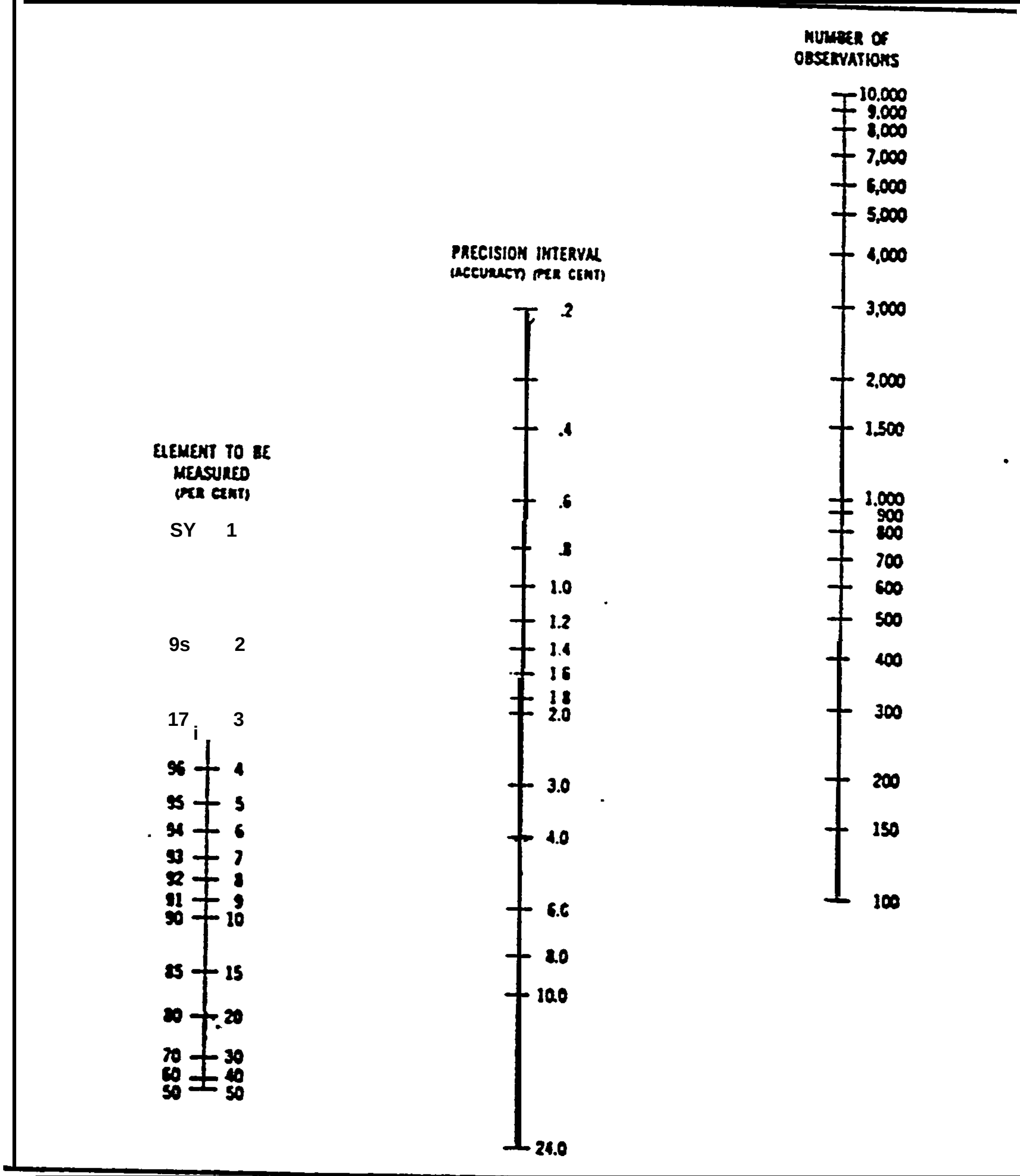


Chart 1
NUMBER OF OBSERVATIONS

A. ______% Activity measure located on left-hand line.

B. ______ Number of readings taken. Mark on right-hand side.

c. **Connect points with a straight line and read the precision interval on the center** line _____%. Divide it by the percent of occurrence of the activity marked on the left line.

$$\frac{\text{Precision Interval}}{\text{Activity Percent}} = \text{Percent Accuracy}$$

VIII. Summarize Results

Value Added	______%
Semi-Value Added	______%
No Value Added	______%
Tacking -	______%
Receiving Instructions	______%
Remove Slag	______%
Material Handling	______%
Miscellaneous Work	______%
Personal	______%
Not In Area	______%
Talk to Other Worker	______%

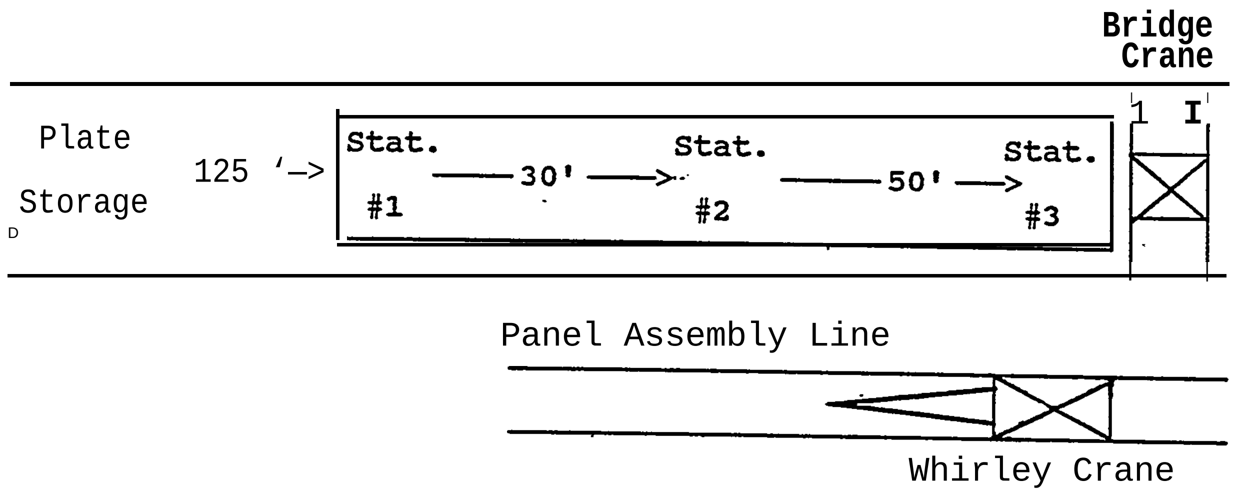
AM	______%
PM	______%

Did the study verify **your assumption that the No Value activities** were high? **And can the output actually be increased if the no** value activities are **addressed and eliminated or at least reduced to a minimum?**

PROCESS CHART EXERCISES

TYPICAL PANEL ASSEMBLY OPERATION

The fabrication of panel assemblies can be done a number of ways. For this exercise, we will utilize a panel line which has three work stations the first being the fitting station and stations 2 and 3 will be utilized for welding the assembly first on one side then the other.



PANEL **ASSEMBLY SEQUENCE**

- **Edge Prep plates are** stored in a stack 125′ from Panel Station #1.
- The overhead bridge **crane moves the 1st plate to Station #1** (.2 hours) .
- The **fitter at Station #1** positions the 1st plate in the clamping fixture (.1 hours) .
- The overhead bridge crane is signaled to bring in the 2nd plate. However, it is busy servicing the burning machines at the far end of the crane bay (.5 hours).
- The **overhead bridge crane moves the 2nd plate to Station #1** (.2 hours) .
- The fitter at Station #1 positions the 2nd **plate up against** Plate #1 **and activates** clamping mechanism. (.1 hours) .

- Tack Plates #1 and #2 together with 1 1/2" tacks spaced 18" apart (1.0 hours).
- Inspect tack welds. (.2 hours).
- Reposition Plates #1 and #2 assembly so that Plate #3 can be positioned to Plate #2. (.2 hours).
- Fitter signals for crane to move in Plate #3 but crane is busy (.8 hours).
- The overhead bridge crane moves the 3rd Plate to Station #1 (.2 hours).
- The fitter at station #1 positions the 3rd Plate up against Plate #2 and clamps into position (.1 hours).
- Tack Plates #3 and #2 together with 1 1/2" tacks spaced 18" apart (1.0 hours).
- Inspect tack welds (.2 hours).
- Fitter needs to move completed plate assembly to Station #2 for welding. However, another panel assembly is currently being welded at Station #2 and he must wait (.5 hours).
- Assembly moved to Station #2 by conveyor (.5 hours).
- Welder at Station #2 welds 1st seam with submerged Arc machine (.6 hours).
- Welder welds 2nd seam with submerged Arc machine (.6 hours).
- Welder at Station #2 has completed the assembly, but can't move assembly to next station until it is cleared. (.6 hours).
- Assembly moved to Station #3 by Conveyor (.3 hours).
- Welder at Station #3 has signaled for a whirley crane to turn assembly over. The crane is currently servicing another work station. (.7 hours).
- Whirley crane turns panel assembly over at Station #3. (.2 hours).
- Welder at Station #3 welds seam #1 on back-side of panel assembly with submerged Arc (.5 hours).
- Welder at Station #3 welds seam #2 on back-side of panel assembly with submerged Arc (.5 hours).
- Welder inspects welds for pin holes (.2 hours).
- Welder signals for crane, which is just finishing another task.

(.4 hours).

0 Whirley crane removes panel assembly from panel line and moves it to the next work station 100’ away (.3 hours) .

FLOW PROCESS CHART

SUBJECT Panel Line Assembly Operation (A 3 Plate Assembly) DATE August 31, 1988

CHART BEGINS Plate Storage Area

CHART ENDS Panel Assembly Removed From Line

SYMBOLS	DESCRIPTION	REF.	DISTANCE MOVED IN FEET	UNIT OPER TIME IN HOURS	UNIT TRANS TIME IN HOURS	UNIT INSPECT TIME IN HOURS	DELAY TIME IN HOURS	STORAGE TIME IN HOURS
▽ 1	Plates in Storage Area							N/A
⇨ 1	Plate #1 to Stat. #1 (Crane)		125		.2			
○ 1	Plate #1 Position (Fitter)			.1				
D 1	Wait for Crane						.5	
⇨ 2	Plate #2 to Stat. #1 (Crane)		125		.2			
○ 2	Plate #2 Pos. to Pl #1 (Fitter)			.1				
○ 3	Tack Plate #1 & #2 (Fitter)			1.0				
□ 1	Inspect Tacks & Seam (Fitter)					.2		
○ 4	Reposition Plane #1 & #2			.2				
D 2	Wait for Crane						.8	
⇨ 3	Plate #3 to Stat. #1 (Crane)		125		.2			
○ 5	Plate #3 Pos. to Pl #2 (Fitter)			.1				
○ 6	Tack Plane #3 to #2 (Fitter)			1.0				
□ 2	Inspect Tacks & Seam (Fitter)					.2		
D 3	Wait on Station #2						.5	
⇨ 4	Move Assembly to Station #2		30		.2			
○ 7	Weld Seam #1			.6				
○ 8	Weld Seam #2			.6				
D 4	Wait on Station #3						.6	
⇨ 5	Move Assembly to Station #3		50		.3			
D 5	Wait for Whirley Crane						.7	

FLOW PROCESS CHART

SUBJECT Panel Line Assembly Operation (A 3 Plate Assembly) DATE August 31, 1988

CHART BEGINS Plate Storage Area

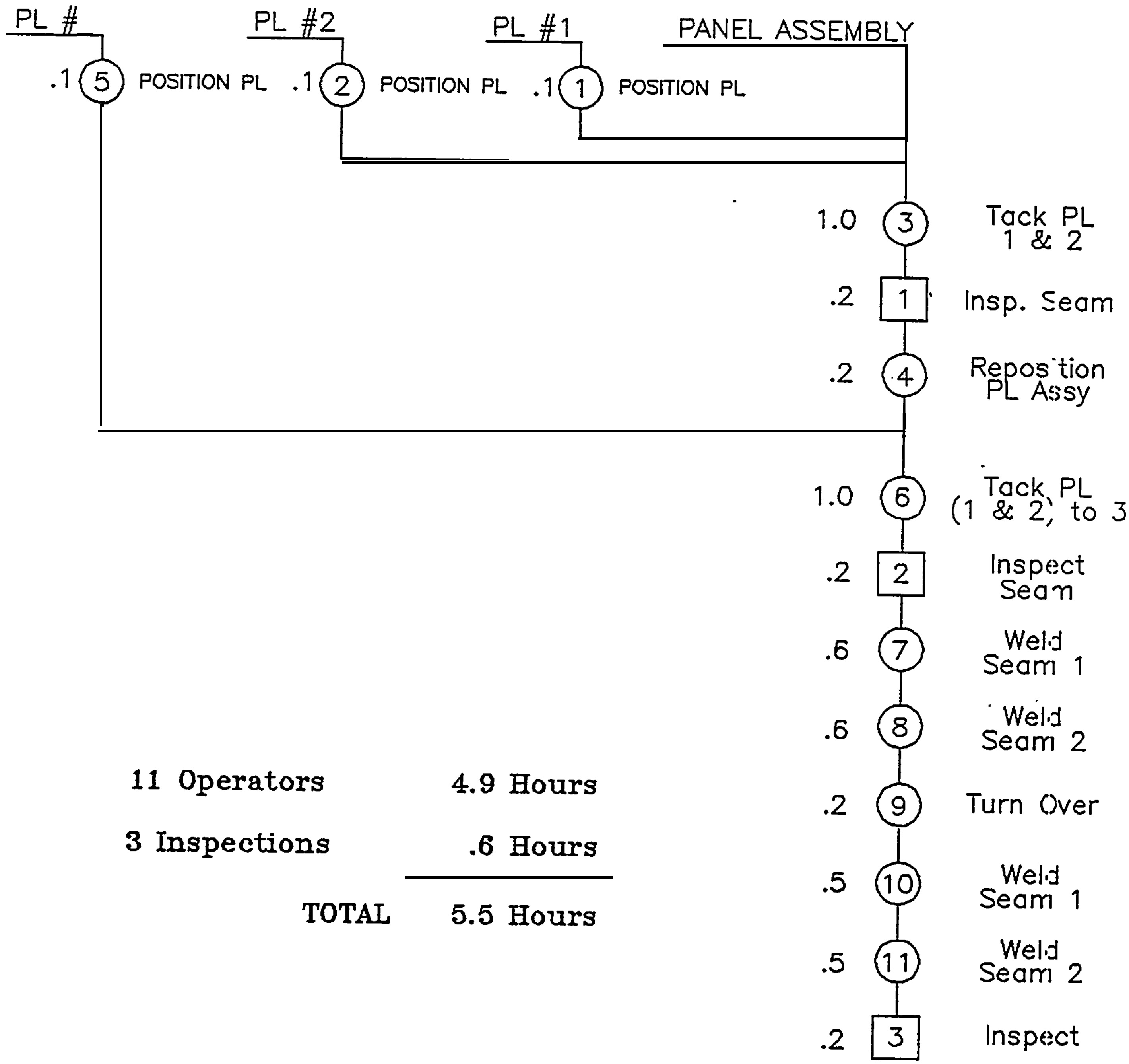
CHART ENDS Panel Assembly Removed From Line

SYMBOLS	DESCRIPTION	REF.	DISTANCE MOVED IN FEET	UNIT OPER TIME IN HOURS	UNIT TRANS TIME IN HOURS	UNIT INSPECT TIME IN HOURS	DELAY TIME IN HOURS	STORAGE TIME IN HOURS
9	Turn Assembly Over			.2				
10	Weld Seam *1 Backside			.5				
11	Weld Seam *2 Backside			.5				
3	Inspect Welds					.2		
6	Wait for Whirley Crane						.4	
6	Assembly Removed		100		.3			
11 6 6 3 1	TOTALS		555	4.9	1.4	.6	3.5	---

OPERATION PROCESS CHART

Subject Charted: Panel Assembly Drawing No.: A2-XYZ

Date: August 31, 1988 By: J. Ruecker



11 Operators	4.9 Hours
3 Inspections	.6 Hours
TOTAL	5.5 Hours

FLOW PROCESS CHART

SUBJECT ______________________________ **DATE** ______________

CHART BEGINS ______________________________
CHART ENDS ______________________________

SYMBOLS	DESCRIPTION	REF.	DISTANCE MOVED IN FEET	UNIT OPER TIME IN HOURS	UNIT TRANS TIME IN HOURS	UNIT INSPECT TIME IN HOURS	DELAY TIME IN HOURS	STORAGE TIME IN HOURS
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APPENDIX F: FLOW PROCESS CHART EXERCISE

METHODS IMPROVEMENT WORKSHOP

FLOW PROCESS CHART EXERCISE

It's Saturday afternoon at the Jones' household. Mr. Jones was out working, leaving Mrs. Jones at home all by herself. After cleaning the house, she sat around thinking of what other chores she could accomplish before her husband got home. She saw that the grass was long and in need of a good trimming. She decided to cut the lawn, and went to get the lawn mower out of the garage. out at the lawn she checked the mower for gas and found out that it was empty. Disgusted, she went back to the garage to get gas. She returned to the lawn and poured gas into the mower. She then proceeded to cut the lawn. After about ten minutes, she noticed that the mower was not performing properly. She inspected the blades and found them to be very blunt. Now infuriated, she hauled the mower back into the garage, detached the blades and started to sharpen them. When she was done sharpening the blades, she attached them back to the mower and headed out to the lawn. Finally, she was back to cutting grass again. Without any further delays or complications, she was finished with the chore. She cleaned up the mower and took it back to the garage for storage.

TIME AND DISTANCES

- lawn to garage after blades inspection - 350 ft., 7 min.
- lawn to **garage at completion - 300 ft., 8 min.**
- **sharpening blades - 30 min.**
- **clean** mower - 15 min.
- garage to lawn - 200 ft., 5 min.
- cutting lawn - 50 min.
- checking for oil - 2 min.
- retrieving gas frOm garage - 6 min.
- pouring gas in mower - 5 min.
- blades inspection - 3 min.
- putting gas away - 30 ft., 10 min.
- checking for gas - 2 min.
- garage to lawn after sharpening blades - 350 ft., 7 min.

FLOW PROCESS **CHART**

SUBJECT ______________________________ DATE ____________

____

C,HART BEGINS ______________________________________
CHART ENDS ____

SYMBOLS	DESCRIPTION	REF.	DISTANCE MOVED IN FEET	UNIT OPER TIME IN HOURS	UNIT TRANS TIME IN HOURS	UNIT INSPECT TIME IN HOURS	DELAY TIME IN HOURS	STORAGE TIME IN HOURS
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TASK-TIME BREAK DOWN

DEPARTMENT__________________ NAME____________________ DATE___/___/___

SECTION ________________ JOB TITLE__________________ SUPV.______________

TIME	ACTIVITY	EXPLANATIONS (ACTUAL WORK, INTERRUPTIONS, ETC.)	UNITS COMPLETE
7:00-7:30			
7:30-8:00			
8:00-8:30			
8:30-9:00			
9:00-9:30			
10:00-10:30			
10:30-11:15			
		LUNCH	
11:45-12:30			
12:30-1:00			
1:00-1:30			
1:30-2:00			
2:00-2:30			
2:30-3:00			
3:00-3:30			
Overtime			

DAILY WORK LOG

Name: ______________________________ Date: __/__/__

Employee #: ______________________ Dept: Steel ____________

Contract #: ______________________ Assembly #: ____________

ACTIVITY	HOURS	COMMENTS
Cutting		
Burning		
Fitting		
Layout		
Set-up		
Clean-up		
Supervision		
Delay-Due to Locating Materials		
Machine Downtime		
Other:, ________________		
Vacation		
Sick Leave		
Total Hours		

APPENDIX H: **SAMPLE WORKSHOP AGENDA**

METHODS IMPROVEMENT WORKSHOP

AGENDA

DAY 1

Workshop Overview & Introductions	**8:30** am
Need for Change	**9:00 am**
-Video "This Thing Called Change"	
BREAK	**10:00** am
Your Role in Change	**10:20** am
Outline Methods Improvement Steps	**10:45 am**
Identify Problem	**11:00 am**
-Nominal Group Techniques (NGT)	
LUNcH	**12:00 pm**
NGT Session	1:00 pm
Identify Perceived Causes	2:15 pm
*BREAL *	2:40 pm
Data Collection Techniques	3:00 pm
-Worksampling	
RECESS	4:00 pm

METHODS IMPROVEMENT WORKSHOP

AGENDA

DAY 2

Questions/Review **Day 1**	**8:30 am**
Worksampling Exercise	**9:00 am**
BREAK	**10:10** am
Worksampling Exercise (Cont.)	**10:30** am
LUNCH	**12:00 pm**
Data Collection Techniques	**1:00 pm**
- Process Charts	
BREAK	2:00 pm
- Self Logging	2:15 pm
- Surveys	
Solution Identification	2:45 **pm**
Implementation/Follow Up	**3:00 pm**
Summary	**3:15 pm**
-Examples	
-Questions	
-Evaluation	
ADJOURN	**4:00 pm "**

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